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ON THE DISTANCE AND MOTION OF THE CLUSTER *PRÆSEPE*.

By BANCROFT WALKER SITTERLY.

DR. KOHLSCHÜTTER in a recent paper[1] describes an investigation into the relation between magnitude and spectral type in Boss's *Taurus* cluster and in *Præsepe*, based on objective prism plates taken at Potsdam. He finds that the relation is the well-known one of Russell's dwarf classification with a few giants also present[2]. Assuming that stars of the same type in the two clusters have the same average real brightness, he determines the parallax of *Præsepe* to be 0″.0072; and shows that this parallax fits excellently with SCHWARZSCHILD's[3] suggestion that the motions in space of *Præsepe* and *Taurus* are the same. The present writer has repeated KOHLSCHÜTTER's process, using the stars of the *Taurus* and *Præsepe* clusters which are found in the *Henry Draper Catalog*. All Boss's stars are in the catalog, and their magnitudes and spectra are given in Table I. For *Præsepe*, VAN RHIJN[4] has determined the proper-motions of its stars down to the thirteenth magnitude. Those above magnitude 9.0 show a conspicuous group-motion[5]. There are forty-one of them; all but four have the position-angles of their motions in the third quadrant, and these thirty-seven give

μ (centennial) $= 3''.52 \pm 0''.07$ $\psi = 240^\circ.8 \pm 1^\circ.0$

The fainter stars show no such preference; their motions are in all directions; and it was decided to pick out from them those stars whose motions were within 1″ per century of the mean of the brighter stars (*i. e.*, for which $\sqrt{(\mu_x - 3''.0)^2 + (\mu_y - 1''.7)^2} < 1''$). Sixty-five probable members of the system, down to the thirteenth magnitude, were thus selected.

TABLE I. THE *Taurus* CLUSTER

H D	Visual Magni.	Spectrum	H D	Visual Magni.	Spectrum
27130	8.3	G5	28099	8.0	G0
371	3.9	G8	205	8.0	G0
383	6.9	G0	294	6.0	F0
397	5.6	F0	305	3.6	K0
459	5.3	F0	307	4.0	K0
483	6.1	F2	319	3.6	F0
561	6.7	F0	344	7.6	G0
628	5.8	A3	355	5.1	A5
691	7.1	G0	485	5.7	F0
697	3.9	K0	527	4.8	A5
749	5.7	A2	546	5.5	A5
819	4.8	A5	556	5.5	F0
835	8.8	G0	568	6.7	F2
836	7.6	G0	677	6.0	F0
848	7.8	F8	910	4.8	A5
859	8.0	G0	28992	8.4	F8
962	4.2	A2	29310	7.8	G6
27991	6.4	F8	375	5.8	F0
28034	7.4	G0	29488	4.8	A3
28052	4.6	A5			

Seven of these, and thirty-five out of the thirty-seven brighter stars are in the *Henry Draper Catalog*. The forty-two are given in Table II. Figure I shows both clusters plotted together, magnitude against spectral type.

There is considerable systematic difference between KOHLSCHÜTTER's magnitudes and spectral types and those of the *Draper Catalog*, but the character of the relation is not affected. The decrease in brightness with increasing redness is sensibly linear in the *Taurus* cluster. In *Præsepe* the decrease is less regular. The

[1] A. KOHLSCHÜTTER, *Astronomische Nachrichten*, 5055 (211, 289, 1920).

[2] H. N. RUSSELL, *Popular Astronomy* 22, 275–294 and 331–351, 1914.

[3] K. SCHWARZSCHILD, *Astronomische Nachrichten* 4681 (196, 9, 1913).

[4] P. J. VAN RHIJN, *Publications of the Astronomical Laboratory at Groningen*, No. 26, 1916.

[5] KOHLSCHÜTTER, *loc. cit.*, p. 299.

TABLE II. *Præsepe*

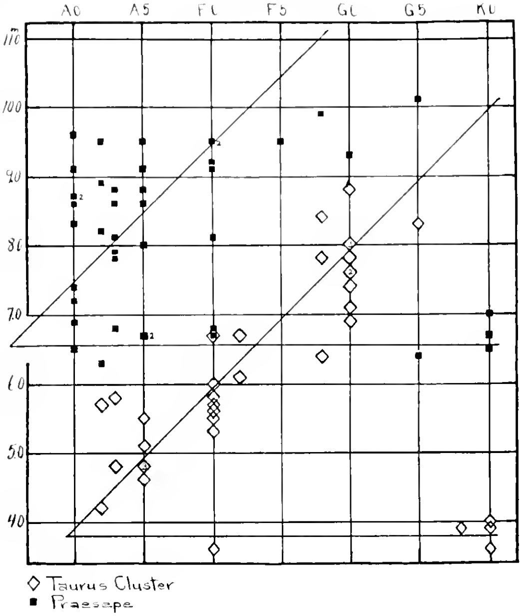
Van Rhijn	H D	Vis. Mag.†	Spectrum	Van Rhijn	H D	Vis. Mag.†	Spectrum
16	73081	9.9	F8	286*	73730	8.7	A0
38	161	9.1	F0	292*	729	9.4	A0
40*	174	8.3	A0	300*	731	6.3	A2
45*	175	8.2	A2	318	746	9.1	A5
50*	210	6.7	A5	328*	785	6.7	A5
114*	345	8.6	A5	340*	798	8.9	A2
124*	397	8.8	A5	348*	819	6.8	A3
146	429	9.5	F5	350*	818	9.5	A2
150*	449	8.4	F0	370	851	9.5	F0
154*	450	8.6	A0	375*	872	8.8	A3
203*	574	8.4	A3	385*	890	8.6	A3
204*	575	6.7	F0	428*	974	7.0	K0
207*	576	7.8	A3	429*	73993	9.2	F0
212*	598	6.7	K0	445*	74028	7.9	A3
224*	618	6.9	A0	449*	050	8.0	A5
226*	616	9.5	A5	459	058	9.5	F0
229*	619	7.2	A0	496	74186	9.3	G0
232	617	9.6	A0				
239	640	10.1	G5				
253*	665	6.5	K0				
265*	666	6.5	A0				
276*	711	7.4	A0				
279	709	8.7	A0				
283	710	6.4	G5				
284*	73712	6.8	F0				

* Stars used in determining mean proper-motion.
† To obtain absolute magnitude, subtract 6.3 from these values.

later-type stars in *Præsepe* fall noticeably below the line drawn, in the figure, with the slope that fits the *Taurus* stars; but if the fifty-eight stars too faint for the *Draper Catalog* were added they would very much raise the average here. In fact, since the mean magnitude of these omitted stars is 11.4, if their mean spectral type is G0 the point representing their mean will fall almost exactly on the line. It is clear that the clusters are similar in general makeup, even to the presence in each of a group of giants travelling with the dwarfs.

Magnitudes in the two clusters were compared, type for type. The means of the A2 and A3 stars were taken together, the A5 stars by themselves, the F0, F2 and F5 stars together, and all the "giants" by themselves. In the *Taurus* cluster all the stars above

FIGURE 1



$4^m.1$ and in *Præsepe* all above $7^m.1$ were considered giants. The A0 stars in *Præsepe* could not be used, for there are no *Taurus* A0's. Of the F8, and G stars only those in the *Taurus* cluster which were of 7.6 or brighter were included, since this limit appeared to correspond approximately to the cutting-off of the *Præsepe* stars at 10.1 by the magnitude limit of the *Draper Catalog*. The groups were weighted according to the number of stars in each, but the F8-G group was given half weight. The results appear in Table III. The ratio of the parallax of *Præsepe* to that of the *Taurus* cluster comes out 0.229 ± 0.017.

The parallax of the *Taurus* cluster is very well determined by four different methods. From the motion Boss[6] made it 0″.025. KAPTEYN's[7] trigonometric determination gave 0″.023. ADAMS[8] obtained 0″.024 by the spectroscopic method, and HERTZSPRUNG[9] from the apparent contraction of the group

[6] L. BOSS, *Astronomical Journal* 604 (26, 31, 1908).
[7] J. C. KAPTEYN, *Publications of the Astronomical Laboratory* at Groningen, No. 23, 1909.
[8] ADAMS, JOY and STRÖMBERG, *Publications of the Astronomical Society of the Pacific*, 32, 194, 1920.
[9] E. HERTZSPRUNG, *Astronomische Nachrichten* 5000 (209, 113, 1919).

TABLE III

Spectrum	*Taurus* Mean Magn.	*Taurus* No. of Stars	*Præsepe* Mean Magn.	*Præsepe* No. of Stars	Magn. Diff.	Wt.
A2-A3	5.12	4	8.48	8	3.36	6
A5	4.93	6	8.80	5	3.87	5
F0-F2-F5	5.94	10	9.15	6	3.21	8
F8-G0-G5*	7.32	5	9.77	3	2.45	2†
Giants‡	3.80	5	6.66	10	2.86	7

Weighted Mean = 3.2 ±0.16

$$\frac{\text{Parallax of } Præsepe}{\text{Parallax of } Taurus} = 0.229 \pm 0.017$$

* For *Taurus*, stars above $7^m.7$, for *Præsepe*, above $10^m.2$.
† Half weight.
‡ For *Taurus*, all stars above $4^m.1$, for *Præsepe*, all above $7^m.1$.

caused by its recession found 0″.027. The mean is 0″.024 ±0″.001, whence the parallax of *Præsepe* is

$$0''.0055 \pm 0''.0006$$

The proper-motion of *Præsepe* is very nearly toward the convergent of the *Taurus* cluster, and SCHWARZSCHILD[10] pointed out that if the two clusters really have the same actual speed and the same convergent the parallax should be 0″.0063, given the speed 44 km./sec., the proper-motion 0″.036 per year and the distance from the position of *Præsepe* on the sky to the convergent, 37°.5. The radial velocity would be 34.8 km./sec. and the position angle of the proper-motion 255°. He found the observed radial velocity 36 km./sec. a very close agreement, and his parallax is only 0″.0009 less than KOHLSCHÜTTER's and 0″.0008 greater than the result of the present paper. KOHLSCHÜTTER, from his own slightly different values, obtained by the same method 0″.0058.

All this is strong evidence for the connection between the clusters, but the position angle of the proper-motion is discordant. The observed angle of the motion is 241° with a probable error of only 1°. The actual error may well be greater, but it seems unlikely that it is ten times as great. For the error in the *Taurus* convergent is given by Boss[11] as no more than 1°.5 in right ascension and 0°.3 in declination, so that practically the whole fourteen-degree shift must come in the angle at *Præsepe*.

To put it differently, with the parallax, proper-motion, and radial velocity of *Præsepe* known, its own convergent can be computed; its position comes out $\alpha = 93°.7$, $\delta = -1°.9$, and the velocity in space of the cluster, relative to the *Sun*, is 47.2 km./sec. The velocity is very close to the value of 45.6 km./sec., which Boss gives for the *Taurus* cluster, but the convergent is nine degrees south of his, the difference being almost entirely due to the value of ψ for *Præsepe*.

The proper-motions of *Præsepe* were reduced by VAN RHIJN to the system of Boss's *Preliminary General Catalog*, the reduction depending on nine stars common to VAN RHIJN, Boss, and SCHUR's[12] heliometer measures on the brighter stars of *Præsepe*. These nine stars all belong to the physical cluster. The mean of their proper-motions, taken directly from Boss, gives μ (centennial) = 3″.5 ψ = 239°; VAN RHIJN's proper-motions, reduced to Boss, give μ = 3″.7 ψ = 237°. The proper-motions of the *Taurus* cluster are referred to the same system. Boss himself[13] however finds a probable correction to his system, which changes the mean proper-motions of the clusters to

$$\textit{Taurus:}\ \mu = 11''.36,\ \psi = 104°.2$$
$$\textit{Præsepe:}\ \mu = 3''.24,\ \psi = 241°.1$$

The convergent of the *Taurus* cluster (which was determined not from the mean proper-motion of the cluster but from the variation of proper-motion with position among the separate stars) is not appreciably shifted by the substitution of these new values. The convergent of *Præsepe* is moved more than three degrees toward the cluster and the velocity becomes 45.8 km./sec., only 0.2 km. greater than that of the *Taurus* cluster; but the position angle is changed less than a third of a degree.

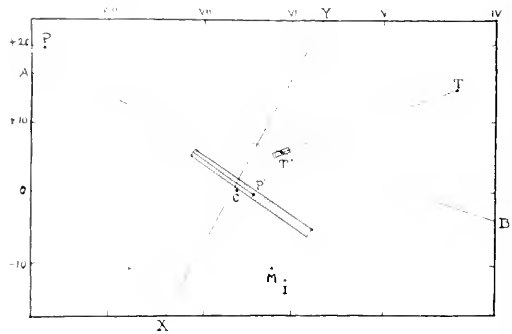
Since the variation in ψ is independent of that in ρ, μ, and π, the uncertainties of these quantities, however large, will not give any leeway for diminishing the distance between the two convergents. The effect on the convergent of these uncertainties was, however, computed by differentiating with respect to ρ, μ, and π the equations for the position of the convergent. The allowable deviations in μ and π were taken equal to their probable errors. In ρ the deviation was estimated from SCHWARZSCHILD's data as about 5 km./sec. The combined deviations of the three quantities gave a maximum allowable deviation in the position of the convergent from ($\alpha = 87°$, $\delta = -7°$) to ($\alpha = 107°$, $\delta = +7°$), using the mean position.

[10] SCHWARZSCHILD, *loc. cit.*, p. 10.
[11] Boss, *loc. cit.*, p. 33.
[12] W. SCHUR, *Astronomische Mittheilungen von der Königliche Sternwarte zu Göttingen*, VIERTER THEIL, 1895.
[13] L. Boss, *Preliminary General Catalog* of 6188 Stars for 1900, p. XXVII.

$$\alpha = 96^\circ.8, \ \delta = -0^\circ.4$$

obtained by applying Boss's correction to the proper-motion. Figure II shows the allowable deviation as a shaded area for each convergent.

FIGURE II



T — Position of *Taurus Cluster*
P — Position of *Præsepe*
T' — Convergent of *Taurus*
P' — Convergent of *Præsepe*
A B — Trace of Plane containing the two clusters and the line of motion of *Taurus*
C — Convergent of 61 *Cygni Group*
M — Convergent of CORLIN's *Monoceros Group*
I — Convergent of KAPTEYN's *Group I*
X Y — Galactic Equator

This figure shows graphically the difficulty of reconciling the facts with the hypothesis of parallel motion. But the practical identity of velocity of the two clusters suggested to the writer that perhaps their paths diverged from a common point in space. In that case, the two paths must lie in the same plane, that is, the trace on the celestial sphere, of a plane containing the positions and motions in space of the two clusters, must pass through both convergents. A trial showed at once that this is impossible; the trace of such a plane, containing the two clusters and the path of the *Taurus* cluster, passes of course through the *Taurus* convergent, but it is almost at right angles to the line joining the convergents, as is shown in Figure II, where the line AB is the trace of the plane.

It would seem then that the connection between *Præsepe* and the *Taurus* cluster is not direct. An indirect connection, on the other hand, is a very reasonable supposition. If we remove the effect of the solar motion[14] from our results, the apices and absolute motions of the clusters are:

Taurus: $\alpha = 93^\circ.5, \ \delta = +29^\circ.0, \ V = 32.0$ km. sec.

Præsepe: $\alpha = 100^\circ.9, \ \delta = +18^\circ.7, \ V = 30.4$ km. sec.

These apices are in the neighborhood of the vertex ($\alpha = 93^\circ.3, \ \delta = 10^\circ.1$)[15] of KAPTEYN's Drift I relative to Drift II. The apices of CORLIN's *Monoceros* Group[16] and the 61 *Cygni* Group[17] are near here, and WILSON[18] notes that the apices of a large proportion of his selected hundred stars fall in the same region. The convergents of the *Monoceros* and 61 *Cygni* clusters and of Drift I, relative to the *Sun*, are charted on Figure II. The 61 *Cygni* convergent is particularly near that of *Præsepe*, but the velocity of that group is much higher than *Præsepe*; moreover, the 61 *Cygni* stars are of F-, G- and K-type only, while *Præsepe* appeares to include all types, those within range of the *Draper Catalog* being mostly A's. It appears, then, that the *Taurus* cluster and *Præsepe* may be considered independent members of Drift I, sharing whatever connection of origin or dynamic influence the membership may signify.

[14] For convenience the solar apex was taken as ($\alpha = 270^\circ$, $\delta = +30$) and the *Sun's* velocity 20 km. sec.

[15] A. S. EDDINGTON, *Monthly Notices of the Royal Astronomical Society* 71, **35**, 1910. EDDINGTON uses a slightly different solar motion, so his apex for Drift I has been corrected here for the difference.

[16] A. CORLIN, *Astronomical Journal* 782 (33, 120, 1920).

[17] B. BOSS, *Astronomical Journal* 633 (27, 69, 1912).

[18] H. C. WILSON, *Lick Obs. Bulletin* 214 (7, 61, 1912).

SUMMARY OF DATA REGARDING *Præsepe*

Position of Center (1900)	$\alpha = 8^h\,34^m \quad \delta = +20^\circ.1$
	(Gal. long. $= 174^\circ$, Gal. lat. $= +34^\circ$)
Parallax, π,	$0''.0055 \pm 0''.0006$
Centennial Proper-Motion, μ,[*]	$3''.21 \pm 0''.07$
Position Angle of Proper Motion, ψ,[*]	$241^\circ.4 \pm 1.0$
Radial velocity, ρ,	36 km. sec.†
Convergent relative to *Sun*,[*]	$\alpha = 6^h\,27^m \quad \delta = -0^\circ.4$
	(Gal. Long. $= 179^\circ$, Gal. lat. $= -3^\circ$)

*Proper-motions referred to Boss's system, with his probable correction applied.
†Uncertain

Apex of Absolute Motion.* $\alpha = 6^h\, 44^m \quad \delta = +18^\circ.7$
(Gal. long. = 164°, Gal. Lat. = +9°)

Absolute Velocity in Space.* 30.1 km./sec.

Distribution of Stars:

Spectrum	Absolute Magnitude +0 to 0.9	1.0 to 1.9	2.0 to 2.9	3.0 to 3.9
A0	3	1	5	1
A2-A3	2	4	3	1
A5	2	1	3	1
F0-F2-F5	2	1	2	3
F8-G0-G5	1	0	0	3
K0	3	0	0	0

No. of probable members of system, down to visual magnitude 13 (absolute magnitude 7) 100
Diameter of Cluster 3 parsecs

*Proper-motions referred to Boss's system, with his probable correction applied.

Princeton University Observatory,
April, 1921.

OBSERVATIONS OF THE SATELLITES OF *URANUS*,

WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY,

By ASAPH HALL.

[Communicated by Captain W. D. MacDougall, U. S. Navy, Superintendent.]

Date	G. M. T.	p	G. M. T.	s	Comp.	See'g	Remarks
			Uranus — Titania				
	h m s	°	h m s	″			
1920 Aug. 8	16 59 1	166.76	17 3 1	31.44	4 , 4	f	Power 367.
21	16 14 23	344.61	16 15 44	31.77	4 , 4	g	Faint. Haze. Fog.
Sep. 3	17 1 47	165.48	17 1 33	31.06	4 , 6	f-g	Faint. Haze
4	16 39 25	176.28	16 43 42	26.56	4 , 4	g	Faint.
15	15 9 34	329.63	15 12 57	19.78	4 , 4	f	Very faint.
16	16 1 46	343.91	16 0 26	31.47	4 , 4	p	
17	14 41 43	354.22	14 42 30	28.75	4 , 4	f	
21	15 29 19	171.13	15 31 49	30.31	4 , 4	f	Faint. Haze. Moonlight.
Oct. 5	15 7 59	3.88	15 14 46	20.55	4 , 4	p	
14	14 10 37	16.06	14 34 24	15.66	3 , 4	f	Very faint. Haze. Too poor to finish.
17	14 29 34	170.24	14 28 45	31.30	4 , 5	f	Seeing poor for last two p's.
Nov. 4	13 29 11	177.14	13 6 56	27.06	4 , 4	p	
13	13 42 36	179.89	13 43 59	22.96	4 , 4	f	Eyepiece fogged.
			Uranus — Oberon				
1920 Aug. 26	16 1 9	352.59	15 50 34	38.68	4 , 4	f	Faint. Haze. Moonlight.
Sep. 2	15 37 43	174.84	15 45 6	35.68	4 , 4	f	Faint.

Date		G. M. T.	p	G. M. T.	s	Comp.	See'g	Remarks
			Uranus — Oberon (Continued)					
		h m s	°	h m s	″			
1920 Sep.	3	15 53 39	188.37	16 4 55	22.54	4 , 4	g	Faint. Haze.
	14	15 1 4	165.32	15 7 30	41.39	4 , 4	p	
	15	16 35 2	172.58	17 10 58	39.58	2 , 4	f	Stopped by clouds.
	21	16 13 34	347.03	16 14 0	42.67	4 , 4	g	Moonlight.
	22	15 8 15	353.92	15 10 48	38.32	4 , 4	f	Very faint. Haze. Moonlight.
Oct.	5	15 57 5	350.47	15 59 29	40.76	4 , 4	p	
	11	15 9 12	166.77	15 10 27	41.53	4 , 4	f	Faint. Haze.
	15	14 18 21	291.07	14 22 41	42.72	4 , 4	g	Very faint. A little fog. Measures prob. rough.
	17	15 52 15	340.09	15 54 54	39.18	4 , 4	f	Apparently a little fog.
Nov.	13	14 39 28	340.51	14 39 26	38.84	4 , 4	f	Power 388. Eyepiece fogged.

Seeing: g = good, f = fair, p = poor. Power 495 used except as noted.

U. S. Naval Observatory, Washington, D. C.,
1921, August 13.

OBSERVATIONS OF COMETS,

MADE WITH THE $12\frac{1}{4}$-INCH REFRACTOR OF THE DETROIT OBSERVATORY.

By R. A. ROSSITER AND D. B. McLAUGHLIN.

1921		G. M. T.	★	No. Comp.	Comet — ★ $\Delta\alpha$	Comet — ★ $\Delta\delta$	Comet's Apparent α	Comet's Apparent δ	Log $p\Delta$ for α	Log $p\Delta$ for δ	Obsr.
					Comet a 1921 (Reid)						
		h m s			m s	′ ″	h m s	° ′ ″			
Apr.	2	21 57 00.8	1	10 , 10	−0 20.74	+ 8 39.1	20 25 31.91	− 4 33 15.5	9.8835n	0.7928	R
	6	22 10 20.0	3	9 , 7	+0 19.41	− 5 59.8	20 27 54.14	+ 0 24 28.2	9.4719n	0.7676	R
	10	21 51 54.0	4	10 , 10	−0 32.88	− 1 34.6	20 30 34.27	+ 6 14 16.1	9.4851n	0.7281	R
	17	21 47 50.0	5	8 , 12	−0 30.09	+10 20.3	20 36 19.31	+20 45 44.4	9.4744n	0.6429	R
	18	20 52 48.7	6	10 , 10	+0 1.60	− 9 36.3	20 37 20.25	+23 15 7.7	9.5770n	0.5866	R
	25	19 12 49.3	7	10 , 10	−0 29.57	+ 7 18.3	20 48 6.82	+44 52 8.9	9.7702n	0.4610	R
	30	18 16 25.0	8	11 , 11	−0 21.03	− 0 44.4	21 5 32.79	+62 44 13.7	9.9563n	9.9726	R
May	3	19 49 41.8	9	t18 , 14	+0 28.76	− 2 12.9	21 30 11.02	+72 57 54.9	0.1360n	9.8404n	R
	13	15 41 11.4	11	t14 , 11	−0 16.68	+ 1 32.2	6 50 54.66	+79 18 20.0	0.3628	0.3477	R
	18	18 11 16.1	12	t14 , 12	+1 20.17	− 0 26.1	7 37 10.14	+70 55 31.7	0.0006	0.9091	R
June	4	15 55 37.5	14	11 , 12	+0 31.68	− 3 32.7	8 5 26.22	+54 24 34.8	9.8542	0.6959	R
	11	15 0 43.1	15	12 , 10	+0 22.38	+ 4 58.9	8 9 37.08	+50 24 42.4	9.8286	0.6565	R
Apr.	2	21 29 22.7	1	10 , 10	−0 22.35	+ 7 36.7	20 25 30.30	− 4 34 17.9	9.9230n	0.7894	M
	4	21 20 30.4	2	10 , 10	+0 56.51	+ 1 37.9	20 26 40.91	− 2 18 48.4	9.5629n	0.7801	M
	10	21 31 59.8	4	11 , 10	−0 35.53	− 2 56.0	20 30 31.62	+ 6 12 54.7	9.5206n	0.7319	M
	18	20 31 33.3	6	10 , 10	+0 0.88	−11 53.9	20 37 18.53	+23 12 50.1	9.6049n	0.6075	M

1921	G. M. T.	★	No. Comp.	Comet — ★ $\Delta\alpha$	Comet — ★ $\Delta\delta$	Comet's Apparent α	Comet's Apparent δ	Log $p\Delta$ for α	Log $p\Delta$ for δ	Obsr.
				Comet *a* 1921 (Reid) (*Continued*)						
	h m s			m s	′ ″	h m s	° ′ ″			
Apr. 25	18 48 29.4	7	12 , 10	−0 33.67	+ 3 41.2	20 48 2.71	+44 48 31.8	9.7804*n*	0.5289	M
30	19 33 37.3	8	10 , 10	−0 17.10	+ 1 30.6	21 5 34.14	+62 46 50.1	9.9451*n*	9.7247	M
May 3	20 22 59.3	9	*t*16 , 10	+1 16.55	+ 1 51.0	21 30 28.05	+73 2 27.5	0.1055*n*	0.1770*n*	M
13	16 28 53.5	11	*t*16 , 10	+0 19.13	− 2 8.9	6 51 30.47	+79 14 38.9	0.3351	0.5441	M
June 3	16 23 23.6	13	10 , 10	+0 25.45	+ 2 7.7	8 4 43.50	+55 3 43.1	9.8431	0.7395	M

R = R. A. Rossiter M = D. B. McLaughlin

Mean Places for 1921 of Comparison Stars

★	α	Red. to App. Pl.	δ	Red. to App. Pl.	Authority
	h m s	s	° ′ ″	″	
1	20 25 51.86	+0.79	− 4 41 58.2	+3.6	*A. G. Strassburg* 7099
2	20 25 43.59	+0.84	− 2 20 28.9	+2.9	*A. G. Strassburg* 7097
3	20 27 33.86	+0.87	+ 0 30 24.8	+3.2	*A. G. Nicolajew* 5198
4	20 31 6.19	+0.96	+ 6 15 48.9	+1.8	*A. G. Leipzig II* 10189
5	20 36 48.32	+1.08	+20 35 25.9	−1.8	*A. G. Berlin B* 7855
6	20 37 17.56	+1.09	+23 24 46.4	−2.4	*A. G. Berlin B* 7860
7	20 48 35.21	+1.18	+44 44 56.8	−6.2	*A. B. Bonn* 14751
8	21 5 52.64	+1.18	+62 45 5.9	−7.8	*A. G. Helsingfors-Gotha* 11934
9	21 29 10.40	+1.10	+73 0 44.4	−7.9	*A. G. Berlin C* 3036
10	21 29 41.16	+1.10	+73 0 15.7	−7.9	9.4 mag. Connected with * 9 $\Delta\alpha = +30^s.76$ $\Delta\delta = -28''.7$
11	6 51 11.84	−0.50	+79 16 44.8	+3.0	*A. G. Kasan* 1217
12	7 35 49.38	+0.29	+70 55 55.9	+1.9	*A. G. Berlin C* 1099
13	8 4 17.49	+0.56	+55 1 37.9	−2.5	*A. G. Helsingfors-Gotha* 5406
14	8 4 53.98	+0.56	+54 28 10.3	−2.8	*A. G. Harvard* 3055
15	8 9 14.14	+0.58	+50 19 48.1	−4.6	*A. G. Harvard* 3071

1921	G. M. T.	★	No. Comp.	Comet — ★ $\Delta\alpha$	Comet — ★ $\Delta\delta$	Comet's Apparent α	Comet's Apparent δ	Log $p\Delta$ for α	Log $p\Delta$ for δ	Obsr.
				Comet *b* 1921 (Pons-Winnecke)						
	h m s			m s	′ ″	h m s	° ′ ″			
May 5	15 51 16.9	1	11 , 10	+0 6.84	− 8 48.3	17 7 56.16	+44 58 32.2	9.7235*n*	0.2605	R
6	16 26 23.6	2	11 , 10	+0 10.85	− 3 34.5	17 12 24.43	+45 12 55.9	9.6794*n*	0.0867	R
7	16 5 10.1	3	10 , 9	−0 48.62	+ 2 52.7	17 16 47.36	+45 25 52.0	9.7116*n*	0.1898	R
29	18 17 15.1	5	12 , 12	−0 10.49	− 6 58.1	19 58 30.15	+41 18 34.2	9.5865*n*	0.0849	R

1921		G. M. T.	★	No. Comp.	Comet – ★ Δα	Comet – ★ Δδ	Comet's Apparent α	Comet's Apparent δ	log pΔ for α	log pΔ for δ	Obsr.
		Comet b 1921 (Pons-Winnecke) (*Continued*)									
		h m s			m s	″	h m s	° ′ ″			
May	5	16 21 41.8	1	10 , 10	+0 12.22	– 8 25.8	17 8 6.22	+44 58 54.7	9.6854n	0.1115	M
	6	16 5 21.3	2	10 , 10	+0 6.97	– 3 44.0	17 12 20.55	+45 12 46.4	9.7092n	0.1924	M
	7	15 45 51.2	3	10 , 10	–0 52.07	+ 2 44.4	17 16 13.91	+45 25 43.7	9.7342n	0.2770	M
	9	17 0 15.1	4	10 , 10	+1 16.92	– 1 10.8	17 26 24.99	+45 49 46.8	9.6235n	9.8094	M
June	9	16 52 39.9	7	10 , 10	–0 28.55	– 0 55.5	21 55 14.72	+23 32 55.5	9.6386n	0.6397	M

R = R. A. Rossiter M = D. B. McLaughlin

Mean Places for 1921 of Comparison Stars

★	α	Red. to App. Pl.	δ	Red. to App. Pl.	Authority
	h m s	s	° ′ ″	″	
1	17 7 51.66	+2.34	+45 14 26.9	–5.0	*A. G. Bonn* 10995
2	17 12 11.23	+2.35	+45 16 35.1	–4.7	*A. G. Bonn* 11046
3	17 17 33.62	+2.36	+45 23 3.7	–4.1	*A. G. Bonn* 11105
4	17 25 5.68	+2.39	+45 51 1.5	–3.9	*A. G. Bonn* 11199
5	19 59 2.75	+2.53	+11 35 47.7	+0.5	*A. G. Bonn* 13674
6	19 58 38.13	+2.53	+11 25 31.8	+0.5	10 mag. Connected with * 5 $\Delta\alpha = -24^s.62 \quad \Delta\delta = -10' \, 15''.9$
7	21 56 10.18	+2.79	+23 33 45.5	+5.5	*A. G. Berlin B* 8478

ON THE PARALLAX OF BARNARD'S PROPER-MOTION STAR,

By D. T. WILSON.

In *A. J.*, 734, Miss Sayer published a note giving the parallax and proper-motion in right ascension of Barnard's μ Star from ten plates taken at the Dearborn Observatory. Using Miss Sayer's results together with five additional plates taken at the same observatory extending the time up to Sept. 7, 1921, the writer found the following values:

$$\pi = 0''.569 \pm 0''.011, \ \mu = 0''.697 \pm 0''.006.$$

The parallaxes and proper-motions in right ascension of this star determined up to date are:

	A. J.	π ″	″	μ ″	″
Russell	705	0.70	±0.06	–0.765	±0.06
Schlesinger	705	0.50	±0.02	–0.85	±0.04
Mitchell	710	0.47	±0.01	–0.74	
Lee	711	0.52	±0.02		
Van Maanen	755	0.519	±0.006	–0.728	
Kostinsky	*	0.622	±0.022	–0.657	±0.028
Miss Sayer	734	0.557	±0.016	–0.621	±0.038
Mitchell	778	0.539	±0.008	–0.715	
Wilson		0.569	±0.014	–0.697	±0.006
Unweighted mean		0.555		–0.722	

* *A. N.* 4971.

CONTENTS.

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THE VARIABLE STAR *R SCUTI*.

By ELIAS BRESON.

I have continued my observations of *R Scuti* ($18^h 39^m 45^s$, $-5° 51'.4$, 1855.0) published in the *Astronomical Journal* No. 777. The instrument employed was a Busch binocular à prism, "Terlux," 45mm. 10x. The comparison stars were the same as formerly, namely:

Desig.	Name	Mag.	Auth.
β	β *Scuti*	$4^m.47$	R. H. P.
η	η *Scuti*	5 .04	R. H. P.
a	7083 R. H. P.	6 .22	R. H. P.
b	$-6°$ 4913	6 .53	H. A. 45
h	*h Aquilae*	5 .70	
g	*g Aquilae*	5 .80	

Each step equaled $0^m.1$. No correction has been applied for extinction ($-0^m.27$). All estimates are given the same weight. The following color-scale has been employed:

$0^c.0$ = pure white; $0^c.5$ = bluish.
$1^c.0$ = bluish white (yellow tint); $1^c.5$ = greenish.
$2^c.0$ = yellowish-white; $2^c.5$ = faint yellowish.
$3^c.0$ = yellowish.
$4^c.0$ = yellow.
$5^c.0$ = straw-yellow; $5^c.5$ = faint orange.
$6^c.0$ = orange; $6^c.5$ = faint golden-yellow.
$7^c.0$ = golden-yellow; $7^c.5$ = faint reddish.
$8^c.0$ = reddish.
$9^c.0$ = copper-red; $9^c.5$ = red (pure).
$10^c.0$ = deep (blood-) red.

1919		G. M. T.	Est.		Weather	Color
		h m				
Nov.	17	1 55	η 1 R	5.14	clear	8.0
1920						
May	24	11 30	R 1 η	4.94	clear	8.0

1920		G. M. T.	Est.		Weather	Color
		h m				
June	6	9 55	R 1 η	4.94	clouds	8.0
	8	11 5	η 1 R	5.14	hazy	8.0
	10	11 20	η 2 R	5.24	hazy	9.5
	13	10 40	η 1.5 R	5.19	clear	
	15	10 45	η 1.5 R	5.19	hazy	8.0
	16	10 18	η 1 R	5.14	clouds	8.0
	17	10 5	η 1.5 R	5.19	hazy	8.0
	26	11 50	g 2 R	6.00	clouds	8.0
	27	9 55	g 1 R	5.90	hazy	8.0
July	1	10 40	R 1 a	6.12	hazy	8.0
	3	10 45	a 1 R	6.32	hazy	8.0
	5	9 40	a 1 R R 2 b	6.32	hazy	8.0
	6	9 40	a 2 R R 1 b	6.42	hazy	8.0
	7	9 50	a 2.5 R R 0.5 b	6.47	hazy	8.0
	8	10 10	R 0.8 b	6.45	hazy	8.0
	11	9 35	R 0.5 b	6.48	hazy	7.5
	12	9 35	b 0.5 R	6.58	hazy	2.5
	12	10 52	b 2 R	6.73	clearer	3.0
	14	9 18	b 2 R	6.73	hazy	5.5
	16	9 52	b 3 R	6.83	hazy	1.5
	19	9 33	R 0.5 b	6.48	clear	1.5
	21	9 10	R 1.5 b a 1.5 R	6.37	hazy	6.0
	25	9 5	a 1.2 R	6.34	clear	8.0
	27	9 25	a 0.5 R	6.27	hazy	6.0
	28	9 0	a 0.2 R	6.24	(moon)	8.0*
	31	9 8	R 2 a g 1 R	5.96	moon clear	8.0
Aug.	2	9 0	R 1.5 a	6.07	hazy	8.0
	3	9 30	R 2 a	6.02	clear	8.0*
	1	8 35	R 1 a	6.12	hazy	8.0
	8	9 4	R 3 a g 1 R	5.94	clear	8.0

*Glimpses

1920		G. M. T. (h m)	Est.		Weather	Color
Aug.	11	9 51	g 0 R	5.80	clear	8.0
	12	8 28	h 0.5 R	5.75	hazy	8.0
	15	8 20	R 1 h	5.60	clear	8.0
	16	10 20	h 0 R	5.70	hazy	8.0
	18	8 14	h 0 R	5.70	hazy	8.0
	20	8 15	η 2 R	5.24	clear	7.5
	21	9 30	η 0 R	5.04	hazy	8.0
	26	7 15	η 2 R	5.24	haze	8.0
	11	7 0	η 1 R	5.11	hazy	3.0
	12	6 50	η 1 R	5.14	hazy	6.0
	13	7 20	η 1.5 R	5.19	hazy	8.0
	17	6 55	η 3 R	5.31	clear	8.0
	19	6 48	η 3 R / R 3 h	5.37	hazy	8.0
	20	6 48	R 3 h	5.40	hazy	8.0
	21	6 51	R 2 h	5.50	moon	6.0
	27	6 40	R 2 h	5.50	moon	8.0
	28	6 18	R 2 h	5.50	moon	8.0
Oct.	1	6 17	R 2 h	5.50	wind	8.0
	3	6 34	R 0.5 g	5.75	cloud	8.0
	4	6 25	h 0.5 R	5.75	wind	8.0
	5	6 0	h 0.5 R	5.75	wind	6.0
	8	6 20	h 0.5 R	5.75	hazy	8.0
	10	6 15	h 0.5 R	5.75	hazy	7.0
	17	5 19	η 2 R	5.21	clear	7.5
	18	6 0	η 3 R	5.34	clear	7.5
	24	5 38	η 3 R	5.34	hazy	6.5
	30	4 45	η 2 R	5.24	hazy	7.5
Nov.	1	5 10	η 1.5 R	5.19	clear	7.5
	2	5 13	0.5 R	5.09	clear	7.5
	[illegible]	4 22	R 2 h	[illegible]	[illegible]	--
	26	9 15	R 2.5 a	5.97	clouds	8.0
Aug.	4	10 35	R 2.8 a	5.94	clear	9.5
	7	8 55	R 2 a	6.02	clouds	7.0
	8	8 30	R 2 a	6.02	clear	7.0
	10	9 10	R 1.8 a	6.04	clear	7.0
	21	8 30	a 0.2 R	6.24	wind	3.0
	22	8 8	a 0.2 R	6.24	clear	7.0
	23	8 55	R 0.2 a	6.20	clear	7.5
	24	8 5	a 0.2 R / R 3 h	6.23	clear	
	26	8 10	a 0.2 R	6.24	clear	7.0
	28	7 50	a 0.5 R	6.27	clear	7.0
	30	8 15	a 0.2 R	6.24	clear	8.0

[illegible]

1921		G. M. T. (h m)	Est.		Weather	Color
Sept.	5	7 35	a 0.2 R / R 2 h	6.23	clear	
	7	9 5	a 0.5 R / R 4.8 h	6.34	hazy	6.5
	8	7 45	a 0.2 R	6.24	clear	6.5
	9	7 10	a 0.5 R	6.27	clear	8.0
	13	7 13	a 0.5 R / R 2 h	6.30	clear	
	19	7 15	a 0.4 R	6.26	clear	7.5
	20	7 12	a 0.5 R / R 2 h	6.30	hazy	8.0
	27	6 50	R 0.5 a	6.17	clear	7.0
	30	8 0	R 1.5	6.07	clear	8.0
Oct.	2	7 55	R 1.2 a	6.10	clear	8.0
	4	7 20	R 1.5 a	6.07	clear	8.0
	5	6 0	R 2 a	6.02	clear	7.0
	7	6 20	R 3 a	5.92	hazy	8.0
	8	6 20	R 3.5 a	5.87	clouds	7.5
	16	7 17	h 2 R	5.90	clear	8.0
	26	5 46	R 2 h	5.50	clear	9.5

For *R Scuti*:

from 11 5 19 (Min.) to 4 7 19 (Max.) = 51 days
21 5 20 (Max.) to 16 7 20 (Min.) = 53
16 7 20 (Min.) to 8 9 20 (Max.) = 51
8 9 20 (Max.) to 10 10 20 (Min.) = 32
17 7 21 (Max.) to 15 9 21 (Min.) = 60
15 9 21 (Min.) to 26 10 21 (Max.) = 41

Max. Min.

26 10 21 : 5 .50

Period irregular

Amplitude 1919 2m.36

Amplitude 1920 1 .89, 0 .81, 1 .12 — 1m.27 in the mean.

It is seen that the color varies with red in Max. and clearer tints in Min.

H[illegible]ver, Denmark
[illegible] Nov., 1921

A STAR WITH A LARGE PROPER-MOTION, *B. D.* 21° 3781,

By T. P. BHASKARAN, M. A.

The star *B. D.* −21° 3781, mag. 7.8, occurs on three plates taken at the Nizamiah Observatory for the *Astrographic Catalogue;* one of these was centred in Decl. −22° and the other two in Decl. −21°. After

very abnormal differences in a preliminary comparison, it was omitted from the equations for computing the plate constants. Applying the constants derived from the other reference stars, the final residuals of *B. D.* −21° 3781 are (in the sense Hyd-Algiers) in units of 0″.3

	Δx	Δy	Plate No.	Epoch
	−171	+50	1620	1920.20
	−172	+50	1680	1920.38
	−170	+52	1638	1920.29
Mean	−171	+51	....	1920.29

[The positive sign in the column Δy shows that the star is moving south.]

The epoch of the Algiers position — mean of three observations — is 1890.0, so that the annual P. M. derived from these residuals is

R. A. 13h 44m 27s.17, Decl. −21° 35′ 55″.9.

The places of the star, given in the *B. D.* and the Cape Photographic Durchmusterung, though not sufficiently accurate to obtain an independent determination, yet distinctly confirm the existence of a large P. M. of the order derived above.

The star is not to be found in any of the catalogues of Proper Motion stars available here, nor in the list given by VAN MAANEN (*Astrophysical Journal*, Vol. XLI, page 187).

A determination of parallax may perhaps be interesting.

Nizamiah Observatory, Hyderabad (Deccan), India,
1921, Sept.

OBSERVATIONS OF 1921 *JB BARCELONA*,

WITH THE 10-INCH PHOTOGRAPHIC REFRACTOR OF THE U. S. NAVAL OBSERVATORY.

1921	h m s	° ′ ″		″	
Feb. 12.66250	9 1 12.93	+17 24 16.6	8.968*n* 0.540	2.0	*Astr. Bor.* +17.0900, 55, 61, 68, 69, 70, 71
14.64583	8 58 4.32	+16 59 7.7	9.078*n* 0.521	0.9	*Astr. Bor.* +17.0900, 11, 12, 18, 19, 141, 153
Mar. 1.61042	8 38 12.55	+13 50 39.3	8.787*n* 0.570	1.7	*Astr. Bor.* +14.0840, 21, 118, 119, 121, 132
11.58740	8 29 41.60	+11 52 20.5	8.496*n* 0.599	1.7	*A.G. Leipzig I*, 3432–33–40–56–71–73

Observations by GEORGE H. PETERS. Measurements and reductions by ERNEST CLARE BOWER; using WILSON's method, *Goodsell Obs. Pub.* **5**.

U. S. Naval Observatory, Washington, D. C.
1921, Nov. 14

NOTE ON THE RETURN OF TAYLOR'S COMET, 1916 I.

By H. M. JEFFERS.

TAYLOR'S Comet is due at perihelion, neglecting perturbations, on June 13, 1922. This comet is especially interesting in that, in 1916, it developed two nuclei. The conditions of the present return are not favorable for a rediscovery: at perihelion it will be near conjunction with the *Sun*. During the next few months, and again near the beginning of 1923, the position with respect to the *Sun* will be favorable, though because of the great distance the comet will be faint. An ephemeris, based on definitive elements for 1916 (not yet published), is appended for the use of those who might desire to search for it. The perturbations during the present revolution are small, and they have not been considered in the ephemeris.

On the assumption that the perihelion passage takes place 8 days later than predicted, the corrections to the ephemeris on December 11 are: $\Delta\alpha = -7^m.1$, $\Delta\delta = -22'$. For a perihelion time 8 days earlier, the corresponding corrections are: $\Delta\alpha = +7^m.9$, $\Delta\delta = +24'$.

FOR GREENWICH MEAN MIDNIGHT

1921-22	α (1920.0)	δ (1920.0)	log Δ
	h m	° ′	
Dec. 19.5	00 22.5	−16 42	0.306
27.5	28.2	15 10	0.316
Jan. 4.5	35.5	13 30	0.326

These figures will not vary much over the range of the ephemeris.

The brightness is of course uncertain, especially since in 1916 it was subject to irregular fluctuations. For the range of the ephemeris the calculations indicate that the comet is not likely to be brighter than the 14th, nor fainter than the 17th magnitudes.

Iowa State University,
October 31, 1921.

OBSERVATIONS OF COMETS,

MADE WITH THE $10\frac{1}{2}$ IN. EQUATORIAL OF THE UNIVERSITY OF MINNESOTA,

[Communicated by F. P. LEAVENWORTH.]

Date 1921	G. M. T.	☄ — ★ $\Delta\alpha$	☄ — ★ $\Delta\delta$	No. of Comp.	☄ App. α	☄ App. δ	log $p\Delta$ α	log $p\Delta$ δ	★	Obsr.
		Comet 1921 *a* (Reid)								
	h m s	m s	′ ″		h m s	° ′ ″				
Apr. 28	17 57 55	+0 13.41	+ 3 5.8	6 , 6	20 56 28.80	+55 23 31.7	9.856*n*	0.651	1	Lv
29	18 1 32	+0 1.31	− 2 8.3	5 , 6	21 0 26.21	58 58 58.3	9.900*n*	0.617	2	Lv
May 1	17 7 51	+1 46.57	+ 5 4.1	4 , 4	21 11 2.02	65 54 58.4	9.948*n*	0.726	3	Lv
2	16 32 13	−0 39.33	+ 0 26.1	4 , 4	21 18 27.36	69 14 13.3	9.987*n*	0.739	4	Lv
2	16 13 54	−0 18.26	+ 5 5.6	4 , 4	21 18 32.07	69 15 55.9	0.004*n*	0.714	5	Lv
4	17 28 30	−0 41.60	+ 1 4.1	4 , 4	21 41 6.19	75 46 47.1	0.187*n*	0.606	6	Bu
4	18 3 14	−0 15.50	+ 5 9.9	5 , 5	21 44 32.59	75 50 52.6	0.213*n*	0.502	6	Sw
7	15 17 16	+0 12.82	+ 0 30.3	6 , 6	23 26 36.71	83 29 57.7	0.040*n*	0.820	7	Lv
15	15 35 51	+0 43.06	+ 1 48.6	4 , 4	7 17 9.16	75 47 50.1	0.227	9.985	8	Lv
15	16 10 32	−0 56.73	− 0 34.2	4 , 4	7 17 22.83	75 45 27.6	0.227	0.274	8	Bu
17	15 30 53	−0 13.48	+ 1 13.8	5 , 6	7 31 37.70	72 34 58.4	0.138	0.004	9	Lv
June 3	16 19 29	+0 25.60	+ 2 3.7	6 , 6	8 4 43.63	55 3 39.1	9.850	0.668	10	Lv
		Comet 1921 *b* (Pons-Winnecke)								
M 9	18 34 25	+0 30.63	. . . . . .	4 , 0	17 26 18.62	. .	9.460*n*	. . .	11	Lv
9	18 24 21	. . . .	−10 41.9	0 , 3	. . . .	45 50 13.5	. . . .	9.691	11	Lv
June 12	18 41 9	−0 12.12	− 9 15.5	4 , 5	22 25 12.27	+16 18 39.2	9.605*n*	0.724	12	Lv

Comparison Stars

Mean Places for 1921.0 and Reduction to Apparent Place

★	α 1921.0	δ 1921.0	Reduction to App. α	Reduction to App. δ	Authority	
	h m s	° ′ ″	s	″		
1	20 56 14.19	+55 20 33.2	+1.20	−7.3	*A. G. Hels-Gotha*	11796
2	21 0 23.71	59 1 14.2	+1.19	−7.6	*A. G. Hels-Gotha*	11857
3	21 9 14.26	65 50 1.9	+1.19	−7.9	*A. G. Christiania*	3293
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	7 16 26.10	75 45 59.0	0.00	+2.8	*A. G. Kasan*	1329
9	7 31 50.91	72 33 15.2	+0.27	−0.6	*A. G. Berlin C*	1089
10	8 4 17.49	55 1 37.9	+0.54	−2.5	*A. G. Hels-Gotha*	5406
11	17 26 15.61	46 0 59.3	+2.38	−3.9	*A. G. Bonn*	11210
12	22 25 52.13	+16 27 47.1	+2.26	+7.6	*A. G. Berlin A*	9192

The observations were made with the filar micrometer and are direct measures of right ascension and declination.

The observers are F. P. LEAVENWORTH = Lv, C. M. BURRILL = Bu, and P. H. SWANSON = Sw.

Minneapolis, Minn.,
Oct. 12, 1921.

OBSERVATIONS OF ASTEROIDS AND COMETS,

MADE WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY

By ERNEST CLARE BOWER

(Communicated by Captain W. D. MACDOUGALL, U. S. Navy, Superintendent.)

G. M. T.	App. α	App. δ	Obj. − ★ α	Obj. − ★ δ	Comp.	Log pα	Log pδ	Ap. pl. red. of ★ α	Ap. pl. red. of ★ δ	Seeing	★
1921			Asteroid REINMUTH, 1921 Apr. 1								
	h m s		m s					s			
May 9.69513	17 20 20.72	+45 49 58.1	−1 12.97	−1 19.6	f35, 7	9.634n	9.064	+2.58	−5.9	p	2
16.74917	18 6 33.25	+46 29 9.0	+1 24.71	+2 31.6	f40, 8	9.111n	9.863n	+2.47	−2.4	f	3
31.76962	20 18 58.32	+39 23 20.1	+0 31.47	+1 49.2	d10, 8	9.536n	9.851	+2.51	+1.0	f	4
June 14.84638	22 14 34.63	+11 14 9.3	+2 2.11	−5 16.2	f30, 6	9.373n	0.627	+2.20	+9.3	f	5
1921			Comet 1921 *c* (DUBIAGO)								
May 25.63047	9 22 42.47	+37 34 33.9	+0 22.70	−1 34.8	d10, 12	9.710	0.490	+1.18	−1.7	f	6
31.62609	9 55 9.20	+33 58 19.2	+3 57.54	−2 44.5	f30, 6	9.710	0.500	+1.22	−5.2	f	8

Apr. 11. 12m. May 25. Poor observation. Clouds. May 31.6. Poor observation. June 14. Bad observation.

Mean Places of Comparison Stars for Beginning of Year

★	α	δ	Authority
	h m s	° ′ ″	
1	12 53 33.93	+ 6 54 18.7	*Astr. Tul.* +7.1252,31
2	17 25 5.67	+45 51 4.6	*A. G. Bonn* 11199
3	18 5 6.07	+46 26 39.8	*A. G. Bonn* 11722
4	20 18 24.34	+39 21 29.9	*A. G. Lund* 9293
5	22 42 30.32	+11 19 16.2	*A. G. Leipzig I* 9089
6	9 22 18.59	+37 36 13.4	*B. D.* +37.1986 comp. with 7, 1921 May 25; $\Delta\alpha = +1^m 52^s.42$, $\Delta\delta = +0' 22''.4$, 1921.0.
7	9 20 26.17	+37 35 51.3	*A. G. Lund* 4608
8	9 51 10.44	+34 1 8.9	*A. G. Leiden* 4011

U. S. Naval Observatory, Washington, D. C.,
1921 Sept. 23.

ELEMENTS ET ÉPHÉMÉRIDE DE LA PLANÈTE 1920 *HZ*,

PAR M. RENAUX

Les éléments ont été calculés au moyen de huit positions obtenues entre 1920 décembre 1 et 1921 mars 2, et que l'on trouvera prochainement au *Journal des Observateurs*.

Les voici

Époque: 1920 décembre 1.5 TM Greenwich.

$M = 352° 59' 2''.8$
$\omega = 56 26 18 .3$
$\Omega = 21 18 35 .0$ } Écliptique et équinoxe moyens de 1920.0.
$i = 13 3 51 .9$
$\varphi = 10 44 9 .8$

$\log a = 0.7566066$, distance aphélie 9.436
$\mu = 260''.0739$ $T = 13^a.65$.

Constante de grandeur $g = 10.8$.

On a tiré de ces éléments l'éphéméride suivante

(1920.0; 12h TMG)

1921-22		A D	D	Gr.
		h m s	° ′	
Déc.	20	13 23 51	+11 47.0	16.0
	25	26 31	28.8	
	30	28 52	13.6	
Janv.	4	13 30 41	+14 1.4	
	9	32 8	+13 52.1	
	14	33 4	15.6	
	19	33 29	11.7	15.9
	24	33 23	10.2	
	29	32 45	11.0	
Fév.	3	31 34	13.8	
	8	29 50	18.2	15.9
	13	27 33	+13 53.8	
	18	24 45	+14 0.2	
	23	24 26	7.0	
	28	17 40	13.5	
Mars	5	13 29	19.4	
	10	8 57	24.4	
	15	13 4 8	27.4	
	20	12 59 9	27.9	16.0
	25	54 3	+14 26.3	

Opposition: Mars 28.

Il y aurait le plus grand intérêt à obtenir quelques positions de cet astre à la prochaine opposition.

Alger-Bouzaréah,
1921, Novembre [illegible].

CONTENTS.

[illegible] N. Y. [illegible] ASSOCIATE EDITORS [illegible] ARD, ERNEST W[illegible] [illegible] AND R. S. WOODWARD. [illegible] ALBANY [illegible] U. S. A., TO WHOM COMMUNICATIONS [illegible] BE ADDRESSED. PRICE $5.00 THE VOLUME. [illegible] *Dec. 19, 1921.*

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ON THE DAILY VARIATION IN CLOCK CORRECTIONS,

BY W. S. EICHELBERGER AND H. R. MORGAN.

[Communicated by Captain W. D. MACDOUGALL, Superintendent.]

In the *Astronomical Journal*, No. 792, Astronomer M. L. ZIMMER of the National Observatory at Cordoba, Argentina, writes, "in two recent numbers of the *Astronomical Journal*, it was shown that clock corrections determined at or near sunset were uniformly larger by $^s.04$ or $^s.05$ than the corresponding ones determined at or near sunrise. This was fully confirmed by TUCKER and others.... ..In order to determine the form of the curve described during the year, the 6 and 18 hour groups were observed on every favorable occasion during 1920... .. The mean results are represented by the formula, $+^s.02 \sin(\alpha - \odot)$ = (correction to observed transit), practically without residual error."

Early in the year 1921 the U. S. Naval Observatory published the results of the observations made with the 9-inch Transit Circle during the years 1903 to 1911; Publications of the U. S. Naval Observatory, Second Series, Volume IX, Part I. The present paper contains the results of an investigation to find out what evidence is contained in those observations bearing upon the phenomenon presented by MR. ZIMMER.

In July 1909, there were selected for observation on the 9-inch Transit Circle, two groups of six clock stars each, the mean right ascension of the two groups being approximately 6^h and 18^h respectively. Both these groups were observed whenever possible from that date to April 1911, during a period of 21 months, about 2000 observations having been secured. This is the same program, we believe, that was carried out by ZIMMER in 1920. The results of these observations are discussed on pages LXXXIV to LXXXVII of the Observatory volume referred to above, and the conclusions drawn from that discussion are: that the same clock correction results from all night observations independently of the time of transit; that a slightly larger correction, larger by less than $0^s.01$, however, results from twilight observations; and that a decidedly larger value, varying somewhat with the time of transit, results from daylight observations, the afternoon values being larger than forenoon ones. This rapid change in the clock correction, amounting to several hundredths of a second as the time of transit of the star changes from an hour before sunset to sunset, has no counterpart in the hour following sunset and therefore cannot be attributed to an error in the observed time of transit of the form

$$k \sin(\alpha - \odot)$$

The difficulty, if not the impossibility, of accurately determining or of eliminating this daylight effect led to the rejection of all star observations made during daylight in forming the final positions in the above mentioned volume, and such observations should not be used in discussions of the daily variations of clock corrections.

Throughout the period 1903 to 1911, it was the general practice to obtain a clock correction in the morning before sunrise and another in the evening shortly after sunset. The interval between two such clock corrections was rarely even approximately twelve hours, but since in ZIMMER's results the correction to the observed time of transit takes the form of $\sin(\alpha - \odot)$, the difference between two clock corrections at 4 A. M. and 8 P. M. respectively would be 85% of the difference between two corrections at 6 A. M. and 6 P. M. In reducing these clock corrections to a common epoch, the rate used was obtained from a rate formula, page LI of the volume just mentioned, which was found to hold for a period varying

from a few days to a few months. No observation used in this discussion was made by day so that the elimination of the effect of the difference between day and night observations does not enter into the problem.

The instrumental constants were always determined by observation at the time the clock correction was determined, the azimuth of the instrument being determined from observations on a north and a south meridian mark. The positions of the marks were determined several times a week between 5 and 7, A. M. and P. M., by observations of pole stars whose positions were fundamentally determined during the progress of the eight years work. The positions of the clock stars used to determine the clock corrections were derived from 7000 observations on 410 nights during the period under discussion. The full details of the method employed in determining the fundamental right ascensions of the clock stars are given on pages XXXV to LVI of the volume to which reference has already been made. The times of transit of the stars over a fixed reticule were recorded by means of a chronograph key. The clocks used in the observations were kept under constant pressure and constant temperature.

In obtaining the results in the following table, the shortest interval between an evening and a morning clock correction was 6 hours and the average interval was $8^h.4$ arranged approximately symmetrically with respect to midnight. Consequently in accordance with the formula of ZIMMER the mean difference obtained is 80% of the maximum difference for the day. The results depend on 5043 star observations made on 376 different nights.

Time	Interval	No. Nights	Morning Corr. minus Evening Corr.
			s
1903–04	Sept. 10 to June 12	62	−0.005
1904–05	July 11 to June 19	50	−0.009
1905–06	Aug. 21 to May 4	47	+0.001
1906–07	Aug. 23 to June 6	16	−0.002
1907–08	July 25 to June 2	66	−0.006
1908–09	July 6 to April 28	74	−0.005
1909–10	Aug. 4 to May 28	34	−0.001
1910–11	Aug. 22 to April 10	33	−0.005
1903–11		376	−0.004

Any possible residual periodic error in the right ascensions of the clock stars would have no effect on the annual differences.

Another grouping of the data gives:

		No. Nights	Morning Corr. minus Evening Corr.	Mean Interval between Corr's.
			s	h
Jan.	Mar.	95	−0.007	8.7
Apr.	June	65	−0.005	6.7
July	Sept.	88	−0.009	7.4
Oct.	Dec.	128	+0.001	9.4
		376	−0.004	8.4

Increasing this value by 25% we have the maximum daily difference $0^s.005$.

Except on 13 nights, the evening and morning corrections in a pair were determined by different observers, but as the observing program was so arranged that each observer was assigned an equal number of evenings and mornings, errors in the adopted personal equations of the observers should not affect the result. Nevertheless, a second set of data was collected in which the morning and evening clock corrections in any difference were always determined by the same observer, using in this case the morning and the following evening, the maximum interval being 16 hours, and the mean interval $14^h.7$, so that the difference obtained should be 90% of the maximum for the day. In this case there were 202 pairs of clock corrections depending on 2769 star observations, of which 1478 had already been used in the previous determination. Dividing these determinations into five groups, we have

Interval	No. Differences	Morning Corr. minus Evening Corr.
		s
1903 Sept. to 1904 Nov.	40	−0.011
1904 Nov. to 1907 Oct.	41	−0.006
1907 Oct. to 1908 Nov.	40	+0.006
1908 Nov. to 1909 Sept.	41	−0.005
1909 Sept. to 1911 Mar.	40	−0.008
1903 Sept. to 1911 Mar.	202	−0.005

From an examination of the positions of the azimuth marks during the eight years work, it was found that the mean azimuth of the marks near sunrise was $0^s.004$ greater than near sunset. No daily variation in the position of the marks was considered in the reduction of the work as published. To take account of this daily variation in the azimuth of the marks of $0^s.004$, the excess of the evening clock corrections over the morning ones as found above, $0^s.005$, should be increased to $0^s.007$.

It is thus found, by omitting all daylight observations, by eliminating periodic errors from the right ascensions of the clock stars and daily variations in the instrumental constants, and by keeping the clocks under constant pressure and constant temperature, that the daily variation of the clock corrections at the U. S. Naval Observatory for a period of eight years is a negligible quantity.

APPROXIMATE ELEMENTS OF TWO SOUTHERN BINARIES,

By BERNHARD H. DAWSON.

The accompanying elements of the binary stars β 744 and BRISBANE 3574 have been deduced and are presented as first approximations. In each case a trial ellipse was drawn and from it values of e, ☊, i and ω were derived by ZWIERS' method. With these values of ☊, i and ω the observed position angles were reduced to true anomalies, and with values of e differing by successive steps of 0.01 the true anomalies were reduced to mean anomalies with SCHLESINGER'S tables. Selecting that value of e for which the resulting plot of M as function of t was nearest to a straight line, a least squares solution was made for P and T. With these values and those of ω and i previously found, the quantity P — ☊ was computed for each observation and ☊ redetermined from the resulting differences. Finally a was determined by dividing the sum of the observed distances by the sum of the corresponding ratios s/a.

The two stars are similar in many respects. The apparent separation of each has been decreasing throughout the interval covered by the observations, and will reach a minimum in the near future. The earlier measures of distance are so erratic that the determination of the elements must be based almost entirely on the position angles. The observed arcs are 106° and 167° and hence the deduced elements cannot safely be considered as more than approximate. The eccentricities and inclinations are not extreme in either direction. The only really notable element is the major axis of BRISBANE 3574, which results 4″.54 and can hardly be much less than 4″.5. This is extremely large for so faint a star.

2159 β 744; R. A. $4^h\ 17^m.4$; Decl. $-25°\ 58'$ (1900)

ELEMENTS		EPHEMERIS Date	Angle	Dist.
			°	″
T =	1923.22			
P =	100.6 years	1922.00	62.3	0.252
e =	0.48	1923.00	80.1	0.249
a =	0″.74	1924.00	97.2	0.263
ω =	278°.0	1925.00	111.7	0.290
i =	±50.0	1926.00	123.5	0.325
☊ =	161.7	1927.00	132.9	0.363

COMPARISON WITH OBSERVATIONS

Date	Angle O	Angle O−C	Distance O	Distance O−C	Observer	
	°	°	″	″		
1891.78	306.6	+5.3	0.79	+0.01	β	3
94.10	301.4	−4.2	0.59	−0.19	SL	2.1
97.73	312.1	−0.1	0.52	−0.25	SEE	1
98.88	314.0	−0.4	0.81	+0.04	A	1
1900.1	316.8	+0.1	0.89	+0.13	SEE	1
07.01	*330.9	+0.1	0.65	−0.04	LM	1
10.27	339.4	+0.4	0.66	+0.03	I	2
14.07	351.3	−0.2	0.58	+0.05	I	2
16.10	358.8	−1.9	0.52	+0.06	I	2
19.25	21.4	−2.5	0.28	−0.05	δ	2
20.12	36.5	+2.7	0.31	+0.01	δ	3
1920.89	47.1	+0.8	0.25	−0.02	δ	3

*Supposing a mistake of 30°.

BRISBANE 3574; R. A. $11^h\ 20^m.4$; Decl. $-61°\ 6'$ (1900)

ELEMENTS		EPHEMERIS Date	Angle	Dist.
			°	″
T =	1918.48			
P =	342.0 years	1922.40	102.11	1.903
e =	0.58	1924.40	109.61	1.900
a =	4″.54	1926.40	117.12	1.899
ω =	0°.0	1928.40	124.62	1.903
i =	±40.0	1930.40	132.07	1.915
☊ =	87.5	1932.40	139.39	1.936

COMPARISON WITH OBSERVATIONS

Date	Angle O	Angle O−C	Distance O	Distance O−C	Observer	
	°	°	″	″		
1834.20	292.2	−3.0	...	.....	h(R)	1
38.10	296.7	+0.1	6.38	[+1.19]	h(E)	2
51.27	304.8	−0.3	4.71	+0.17	J	2
53.96	303.7	−2.6	4.47	+0.02	J	2
56.21	310.9	+3.0	....	....	J	2
58.11	306.8	−2.5	4.25	+0.02	J	1
1879.03	329.6	[−1.7]	4.32	[+1.30]	CGA	4

Date	Angle O	Angle O−C	Distance O	Distance O−C	Observer	
	°	°	″	″		
1883.42	337.9	−0.5	2.44	−0.36	Hg	1
96.36	10.1	+1.7	2.26	+0.12	Sl	3
1901.25	26.3	+1.3	1.88	−0.12	Tb	2
14.32	60.1	−0.6	2.06	+0.16	I	2
13.31	69.2	+1.0	1.74	−0.16	I	2
14.25	72.2	+0.5	1.86	−0.01	I	2
15.31	74.0	−1.7	1.86	−0.04	V	4
15.36	76.6	+0.7	1.60	−0.30	I	2
1916.38	80.4	+0.7	1.68	−0.23	I	2
1917.38	83.4	0.0	1.83	−0.08	I	2
17.4	81.2	−2.3	2.00	+0.09	V	5
17.55	83.8	−0.2	1.93	+0.02	δ	4
20.27	94.4	+0.2	1.99	+0.08	Tp	4
20.28	94.5	+0.3	1.96	+0.05	δ	4
1921.39	99.5	+1.2	1.83	−0.08	δ	2

La Plata,
1921, November 30.

OBSERVATIONS OF THE SATELLITE OF *NEPTUNE*,

WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY,

By ASAPH HALL.

[Communicated by Captain W. D. MacDougall, U. S. Navy, Superintendent.]

Date			G. M. T.	p	G. M. T.	s	Comp.	Seeing	Remarks
			h m s	°	h m s	″			
1920	Dec.	14	18 53 39	301.805	18 56 38	16.49	4 , 4	f	
		17	18 53 42	120.324	18 59 06	15.98	4 , 4	f	Haze.
		20	18 14 11	298.577	18 19 29	16.44	4 , 4	g	Moonlight.
		31	18 59 43	325.240	18 57 27	15.38	4 , 4	g	Haze.
1921	Jan.	3	16 45 58	147.200	16 44 34	15.24	4 , 4	p–f	
		6	17 06 00	322.966	16 55 49	15.40	4 , 4	f	Haze and clouds. Very faint.
		12	17 27 12	317.451	17 29 18	16.39	4 , 4	f	
		27	15 38 56	129.588	15 38 02	16.70	4 , 4	f–p	
	Feb.	11	14 26 20	299.103	14 27 01	16.93	4 , 6	f	
		11	15 41 25	116.999	15 41 20	16.40	4 , 4	f	
		16	16 59 51	329.609	16 58 24	15.40	5 , 6	f	
		25	14 29 31	146.713	14 10 54	15.74	4 , 5	f	
	Mar.	1	13 49 41	285.423	13 53 58	15.84	4 , 4	f–g	Clouds at first.
		7	14 10 07	278.447	14 08 42	14.55	4 , 1	g–f	Haze. Faint.
		13	17 32 22	261.526	17 42 25	12.38	4 , 4	f	
		18	15 15 02	307.123	15 18 23	17.38	4 , 4	f	Moonlight and haze. Faint.
		25	13 21 18	258.189	13 27 36	12.18	4 , 4	f	
		29	13 23 22	314.737	13 23 29	13.36	4 , 4	f	
	Apr.	1	14 12 50	161.286	14 10 01	13.10	4 , 4	f	
		4	14 11 03	336.394	14 10 02	14.17	4 , 4	g–f	
		5	14 26 59	295.173	14 28 52	16.42	4 , 4	f	
		6	13 38 36	235.172	13 38 46	10.57	4 , 4	f	Faint.
		11	14 29 33	290.079	14 36 16	16.00	4 , 4	f	

Seeing: g = good, f = fair, p = poor. The powers used were as follows: 388, Dec. 14 — Jan. 27, inclusive, also, on Feb. 16; 367 on Mar. 7; 495 and 770 on Mar. 13; and 495 on other dates.

U. S. Naval Observatory, Washington, D. C.,
1921, Sept. 19.

ELEMENTS OF *TEMPEL'S* COMET, *a* 1920,

By FRANK E. SEAGRAVE.

The following elements are based on observations by Prof. George Van Biesbroeck at Yerkes Observatory, July 20, Aug. 21, and Sept. 23, 1920, and published in *A. J.*, 792.

E = 1920, Aug. 21.884 G. M. T.

$M = 13^\circ\ 39'\ 28''.50$		
$\omega = 186\ 41\ 47.79$	$\log e = 9.7499864$	
$\pi = 307\ 29\ 17.99$	$\log a = 0.4783612$	$x = r[9.9920195] \sin(211^\circ\ 25'\ 37''.40 + u)$
$\Omega = 120\ 47\ 30.20$	$\log q = 0.1195142$	$y = r[9.9817112] \sin(124\ 42\ 53.96 + u)$
$i = 12\ 46\ 31.72$	$\mu = 679''.9309$	$z = r[9.5338291] \sin(\ 89\ 17\ 36.54 + u)$

OBSERVATIONS OF THE SATELLITES OF *SATURN*, 1909,

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

By ASAPH HALL and JAMES B. EPPES.

[Communicated by Captain W. D. MacDougall, U. S. Navy, Superintendent.]

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Obs.	Remarks
				Enceladus-Tethys					
	h m s	°	h m s	″					
1909 Oct. 20	10 14 15	279.77	10 31 47	7.94	4 , 4	3	388 , Brt.	Hl	
20	10 58 12	279.72	10 42 32	8.02	4 , 4	3	388 , Brt.	Hl	
25	7 56 54	84.18	8 7 30	10.18	4 , 4	2–3	388 , Brt.	Hl	
25	8 29 30	83.84	8 18 46	9.76	4 , 4	2–3	388 , Brt.	Hl	
Dec. 6	7 28 8	73.01	7 29 3	39.65	4 , 4	2	388 , Brt.	Hl	
6	7 49 14	70.40	7 48 38	36.39	4 , 4	2	388 , Brt.	Hl	
				Tethys-Dione					
1909 Sept. 2	13 13 43	100.63	13 25 51	14.10	4 , 4	3–4	Brt.	Hl	Haze. Clouds.
2	14 0 27	101.10	13 41 52	13.86	4 , 4	3–4	Brt.	Hl	
Oct. 16	8 32 25	102.44	8 51 55	57.78	4 , 1	3–4	388 , Brt.	Hl	
22	9 23 54	84.47	9 33 41	58.36	4 , 1	4	388 , Brt.	Hl	
22			9 42 44	58.01	0 , 4	4	388 , Brt.	Hl	Clouded.
26	11 25 49	106.14	11 38 58	24.54	4 , 4	2–3	388 , Brt.	Hl	
26	12 4 10	103.98	11 48 49	24.85	4 , 4	2–3	388 , Brt.	Hl	
28	8 24 17	336.70	8 41 30	15.62	4 , 4	4	388 , Brt.	Hl	Clouds.
28	8 57 38	325.40	8 47 1	15.84	4 , 4	4	388 , Brt.	Hl	
29	9 13 29	235.65	9 22 41	31.70	4 , 4	3	388 , Brt.	Hl	
29	9 41 14	228.97	9 30 9	30.76	4 , 4	3	388 , Brt.	Hl	
Nov. 4	12 17 9	95.72	12 40 25	97.76	4 , 4	3	388 , Brt.	Hl	
4	13 15 27	94.30	13 0 19	99.23	4 , 4	3	388 , Brt.	Hl	
Dec. 5	7 22 43	31.76	7 30 11	21.74	2 , 2	2	388 , Brt.	Hl	
5	7 41 27	23.46	7 34 16	21.52	2 , 2	2	388 , Brt.	Hl	Clouded.
20	8 14 6	98.76	8 19 43	27.20	2 , 2	2	388 , Brt.	Hl	Moonlight.
20	8 30 20	98.64	8 25 3	26.95	2 , 2	2	388 , Brt.	Hl	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Obs.	Remarks
			Tethys-Rhea						
	h m s	°	h m s	″					
1909 Oct. 22	8 35 6	93.50	8 45 36	127.75	4, 4	4	388, Brt.	HL	
22	9 7 1	93.03	8 56 49	128.26	4, 4	4	388, Brt.	HL	
30	10 19 35	98.99	10 31 29	48.78	4, 4	2 3	388, Brt.	HL	
30	10 49 49	98.57	10 39 3	48.54	4, 4	2 3	388, Brt.	HL	
Dec. 20	10 41 57	80.58	10 19 18	80.74	2, 2	2	388, Brt.	HL	Moonlight.
20	10 31 20	79.92	10 25 53	79.74	2, 2	2	388, Brt.	HL	
			Dione-Rhea						
1909 Oct. 13	9 34 37	75.20	9 47 52	30.76	4, 4	4	388, Brt.	HL	
13	10 7 34	74.29	9 55 31	30.26	4, 4	4	388, Brt.	HL	
13	10 41 12	72.61	10 55 23	27.02	4, 4	4	388, Brt.	HL	
13	11 14 43	71.56	11 3 50	26.95	4, 4	4	388, Brt.	HL	
16	9 8 29	81.68	9 24 29	93.42	4, 4	3–4	388, Brt.	HL	
16	9 45 58	80.65	9 32 47	92.37	4, 4	3–4	388, Brt.	HL	
26	12 28 20	88.48	12 48 7	91.07	4, 4	3	388, Brt.	HL	
26	13 18 57	87.88	13 5 18	90.03	4, 4	3	388, Brt.	HL	
28	9 10 35	357.60	9 21 31	6.16	4, 4	4	388, Brt.	HL	
28	9 36 14	355.14	9 27 54	6.22	4, 4	4	388, Brt.	HL	
29	9 51 41	274.85	10 2 13	87.31	4, 4	3	388, Brt.	HL	
29	10 17 5	274.66	10 8 49	87.35	4, 4	3	388, Brt.	HL	
Dec. 20	8 39 11	77.32	8 48 40	66.93	2, 2	2	388, Brt.	HL	Moonlight.
20	9 0 24	76.46	8 52 33	66.59	2, 2	2	388, Brt.	HL	
			Rhea-Titan						
1909 Oct. 20	8 37 29	90.181	8 58 22	284.36	4, 4	2–3	388, Brt.	HL	
20	9 40 46	89.834	9 18 46	283.75	4, 4	2–3	388, Brt.	HL	
25	8 48 32	323.430	9 0 7	65.20	4, 4	3	388, Brt.	HL	
25	9 25 43	320.143	9 10 56	66.41	4, 4	3	388, Brt.	HL	
25	10 45 10	314.405	10 52 54	75.44	4, 4	3	388, Brt.	EP	
25	11 4 4	313.435	10 57 45	75.78	4, 4	3	388, Brt.	EP	
26	8 39 36	284.546	8 59 39	216.54	4, 4	3	388, Brt.	HL	Moonlight.
26	9 35 33	281.056	9 18 24	217.95	4, 4	3	388, Brt.	HL	
26	9 58 17	280.811	10 20 37	222.63	4, 4	3	388, Brt.	HL	
26	10 56 34	280.388	10 38 5	224.04	4, 4	3	388, Brt.	HL	
27	9 48 17	272.030	9 53 49	241.73	4, 4	3	388, Brt.	EP	
27	10 3 36	271.946	9 58 42	241.39	4, 4	3	388, Brt.	EP	
27	10 9 54	271.933	10 15 42	240.70	4, 4	3	388, Brt.	EP	
27	10 28 55	271.790	10 24 30	240.50	4, 4	3	388, Brt.	EP	
27	10 39 13	271.762	10 49 58	239.47	4, 4	3	388, Brt.	HL	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Obs.	Remarks
			Rhea-Titan — Continued						
	h m s	°	h m s	"					
1919 Oct. 27	11 11 30	271.580	10 59 9	238.57	4 , 4	3	388 , Brt.	Hl	Clouded. Black wires in moonlight for p.
29	8 8 38	265.528	8 15 14	95.38	4 , 4	3	388 , Brt.	Ep	
29	8 26 22	265.702	8 20 49	95.73	4 , 4	3	388 , Brt.	Ep	
29	8 41 25	265.762	8 47 40	95.88	4 , 4	2	388 , Brt.	Ep	
29	8 57 35	265.785	8 52 37	95.88	4 , 4	2	388 , Brt.	Ep	
29	11 38 50	266.295	11 47 43	98.50	4 , 4	3	388 , Brt.	Hl	
29	12 4 48	266.456	11 56 45	98.46	4 , 4	3	388 , Brt.	Hl	
29	12 20 10	266.446	12 34 41	99.37	4 , 4	3	388 , Brt.	Hl	
29	12 59 29	266.605	12 48 13	99.57	4 , 4	3	388 , Brt.	Hl	Moonlight.
30	8 7 50	266.977	8 23 56	145.24	4 , 4	3	388 , Brt.	Hl	
30	8 47 11	266.873	8 35 52	145.78	4 , 4	3	388 , Brt.	Hl	
31	8 46 46	257.253	8 59 54	144.40	4 , 4	3	388 , Brt.	Hl	
31	9 18 3	256.760	9 7 41	143.61	4 , 4	3	388 , Brt.	Hl	
31	9 33 45	256.582	9 47 49	141.80	4 , 4	3	388 , Brt.	Hl	
31	10 10 59	256.050	9 59 59	140.96	4 , 4	3	388 , Brt.	Hl	
31	10 30 46	255.688	10 38 29	138.79	4 , 4	3	360*b*, Brt.	Ep	
31	10 48 44	255.440	10 43 58	138.37	4 , 4	3	360*b*, Brt.	Ep	
Nov. 4	8 51 13	92.746	8 57 50	126.52	4 , 4	3	388 , Brt.	Ep	
4	9 10 7	92.825	9 3 26	126.61	4 , 4	3	388 , Brt.	Ep	
4	9 41 55	92.777	9 53 44	125.02	4 , 4	3	388 , Brt.	Hl	
4	10 7 26	92.907	10 0 46	124.76	4 , 4	3	388 , Brt.	Hl	
6	9 4 11	91.243	9 18 23	233.25	4 , 4	3–4	388 , Brt.	Hl	
6	9 43 34	91.044	9 32 30	233.67	4 , 4	3–4	388 , Brt.	Hl	
6	10 12 37	90.935	10 22 10	235.70	4 , 4	3–4	388 , Brt.	Ep	
6	10 36 47	90.833	10 29 19	235.75	4 , 4	3–4	388 , Brt.	Ep	
16	10 34 45	129.975	10 46 58	46.50	4 , 4	4	388 , Brt.	Hl	Clouds.
16	11 9 1	128.943	10 58 5	46.50	4 , 4	4	388 , Brt.	Hl	
18	7 58 59	152.567	8 9 43	35.08	4 , 4	4	388 , Brt.	Ep	
18	8 20 23	151.696	8 15 32	35.17	4 , 4	4	388 , Brt.	Ep	
18	8 45 9	150.184	8 53 35	36.36	4 , 4	4	388 , Brt.	Hl	
18	9 6 21	149.089	8 58 0	36.42	4 , 4	4	388 , Brt.	Hl	
Dec. 4	11 0 52	99.086	11 23 8	191.22	4 , 4	4	388 , Brt.	Hl	
4	11 46 41	98.786	11 35 10	191.43	4 , 4	4	388 , Brt.	Hl	
6	8 20 58	95.610	8 33 45	109.73	4 , 4	3	388 , Brt.	Hl	
6	8 58 25	95.691	8 46 20	109.68	4 , 4	3	388 , Brt.	Hl	
8	8 13 40	89.911	8 27 28	245.94	4 , 4	4	388 , Brt.	Hl	
8	8 48 18	89.736	8 37 56	246.01	4 , 4	4	388 , Brt.	Hl	
17	8 47 38	223.458	9 2 41	45.08	4 , 4	4	388 , Brt.	Hl	Too poor to finish.
20	10 40 47	128.667	10 52 32	60.34	4 , 4	3	388 , Brt.	Hl	Moonlight.
20	11 11 29	127.413	10 59 52	61.01	4 , 4	3	388 , Brt.	Hl	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Obs.	Remarks
				Rhea-Titan — Continued					
	h m s	°	h m s	″					
1919 Dec. 21	8 2 21	102.395	8 16 38	186.96	1, 4	3	388, Brt.	HL	Moonlight.
21	8 44 37	101.968	8 31 9	188.38	4, 1	3	388, Brt.	HL	
21	9 10 13	101.802	9 12 51	192.33	1, 1	3-4	388, Brt.	HL	Clouded.
				Titan-Japetus					
1909 Nov. 1	10 19 41	332.785	10 29 22	189.96	1, 4	3	388, Brt.	EP	
4	10 41 16	332.418	10 37 33	190.11	1, 4	3	388, Brt.	EP	
4	11 3 37	332.114	11 21 17	190.30	1, 1	2-3	388, Brt.	HL	
4	11 52 10	331.163	11 35 56	190.30	1, 1	2-3	388, Brt.	HL	
6	8 10 36	307.997	8 24 49	204.15	1, 1	3	388, Brt.	HL	
6	8 48 18	307.803	8 37 49	204.13	4, 4	3	388, Brt.	HL	

Titan-Japetus

Date	W. M. T.	Δα	Δδ	Comp.	Seeing	Power and Illum.	Obs.	Remarks
	h m s	s	″					
1909 Oct. 25	11 37 31	+37.533	+138.26	t15, 5	2	388, Brt.	EP	
25	12 3 48	+37.537	+137.93	t15, 5	2	388, Brt.	HL	Japetus faint.
30	11 18 27	+29.061	+201.75	t15, 5	2	388, Brt.	EP	
30	11 33 1	+28.962	+201.86	t15, 5	2-3	388, Brt.	HL	
31	11 10 27	+21.785	+207.75	t15, 5	3	388, Brt.	EP	
31	11 24 0	+21.729	+207.75	t15, 5	3	388, Brt.	EP	
31	11 36 5	+21.573	+207.97	t15, 5	3	388, Brt.	HL	Japetus faint. Haze.
Dec. 6	9 59 41	−38.313	−143.68	t30, 10	3	388, Brt.	HL	

Comp.: t = transits. Seeing: 2 = good, 3 = fair, 4 = poor. Power and Illum.: b = occulting bar over planet, Brt. = Bright field. Obs.: HL = HALL, EP = EPPES.

All observations were taken with Clark II Micrometer, telescope east of pier. Value of one revolution $= 9''.9329 + 0''.0000\,525\,(t' - 50°\text{ F.}) + 0''.0255\,(1^{\text{m}}.280 - \text{focal scale.})$

U. S. Naval Observatory, Washington, D. C.,
1921, Dec. 15.

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THE PROPER-MOTIONS OF 154 RED STARS.

By RALPH E. WILSON.

Recent developments in the realm of astrophysics indicating immense size and rapid motion in the line of sight for certain classes of the red stars, together with the probability that they represent both early and late stages of stellar development, make it of more than ordinary interest that we collect as much information as possible with regard to their motions across the sky. Because of their faintness on the one hand and their variability on the other, these stars have in general been neglected by meridian observers and comparatively little material is available for the determination of their proper-motions. A few of them are found in Boss' *Preliminary General Catalog*, others are scattered here and there in some of the modern catalogs and special proper-motion lists, but the motions of the great majority of them are unknown. When the programs for the Albany observations in both northern and southern hemispheres were made up, a representative number of these stars were included. The approximate completion of the San Luis reductions and the inclusion of a number of the stars in the late catalogs of some of the northern observatories give a comparative wealth of modern data. While well-determined positions prior to 1875 are woefully lacking, a systematic survey of the material available has resulted in the collection of fairly reliable proper-motions of 154 stars, the spectra of most of which are classified as *Md*, *R* and *N*, the remainder being *Mc* variables, and red stars the spectra of which are peculiar or as yet unclassified. Thirty-eight of them have been taken from the *Preliminary General Catalog* and lists by NORLUND[1] and the MISSES YOUNG and FARNSWORTH[2], sufficient material not being available to justify new determinations. The remaining 116 are new proper-motions derived by the writer following the system of the *Preliminary General Catalog*.

The stars are listed in Table I, in the respective columns of which are given the designation, position for 1900, classification of spectra on the Harvard system, proper-motion in right ascension in seconds of time and arc with the probable error, proper-motion in declination with the probable error, total proper-motion and the authority. The letters in the last column signify: *B*, BOSS; *N*, NORLUND; *S*, SCHROETER[1]; *Y*, YOUNG and FARNSWORTH; and *W*, WILSON.

[1]Publications of the Copenhagen Observatory, loc. cit. GYLLENBERG, *Meddelanden fran Lunds Astronomiska Observatorium*, No. 90, p. 13, 1918.

[2]*Astronomical Journal*, Vol. XXXIII, p. 194, 1921.

TABLE I

	Star	α	δ	Spec.	μ_α			μ_δ		μ	
1	*H. D.* 151	0 1.2	−33 22	*Md*	−.0005	−.006	±.007	+.012	±.008	.013	W
2	*S Sculptoris*	10.3	−32 36	*Md*	+ 62	+.077	10	+.036	12	.085	W
3	*T Androm.*	17.2	+26 26	*Md*	+ 08	+.011	19	+.019	09	.022	W
4	*T Cassiop.*	17.8	+55 14	*Md*	+ 75	+.064	12	−.018	21	.066	W
5	*R Androm.*	18.8	+38 1	*R?*	− 15	−.018	12	−.057	13	.060	W
6	*S Ceti*	19.0	− 9 53	*Md*	− 08	−.012	22	+.017	22	.021	W
7	*Z Piscium*	1 10.6	+25 14	*Na*	− 21	−.028	09	−.015	08	.032	B
8	*S Cassiop.*	12.3	+72 5	*Pec*	+ 08	+.004	04	−.047	10	.047	B
9	*S Piscium*	12.3	+ 8 21	*Md*	− 42	−.062	27	−.016	22	.077	W

Star		α	δ	Spec.	μ_α			μ_δ		μ	
10	*R Sculptoris*	1 22.4	−33 4	*Nb*	−.0020	−.025	±.014	−.020	±.010	.032	*W*
11	*R Piscium*	25.5	+ 2 22	*Md*	− 07	−.010	12	+.009	10	.013	*W*
12	*V Arietis*	2 9.6	+11 17	*Nb*	± 00	±.000	27	+.106	25	.106	*W*
13	*R Arietis*	10.4	+24 35	*Md*	+ 26	+.035	13	−.060	14	.069	*W*
14	*o Ceti*	14.3	− 3 26	*Md*	− 01	−.001	03	−.237	02	.237	*B*
15	*R Ceti*	20.9	− 0 38	*Md*	− 29	−.044	21	+.011	19	.045	*W*
16	*H. D.* 16115	30.2	− 9 53	*R3*	+ 06	+.009	14	−.010	11	.013	*W*
17	*Y Arietis*	35.0	+30 17	*Me*	− 12	−.015	10	+.007	11	.017	*W*
18	*T Arietis*	42.8	+17 6	*Me*	− 39	−.056	10	−.025	10	.061	*W*
19	*W Persei*	43.2	+56 31	*Me*	± 00	±.000	.	+.008	.	.008	*N*
20	*H. D.* 19557	3 3.7	+57 31	*R5*	− 08	−.006	16	±.000	26	.006	*W*
21	*H. D.* 20234	10.0	−57 42	*Na*	+ 14	+.011	02	+.007	04	.013	*W*
22	*Y Persei*	20.9	+43 50	*N*	+ 37	+.010		+.011		.012	*N*
23	*T Eridani*	51.0	−24 29	*Md*	+ 18	+.025	15	−.003	16	.025	*W*
24	*T Camelop*	4 30.4	+65 57	*R?*	+ 55	+.014	.	−.007	.	.015	*N*
25	*R Doradus*	35.6	−62 16	*Me*	− 81	−.056	05	−.084	07	.101	*W*
26	*ST Camelop.*	40.9	+68 0	*Nb*	− 18	−.010	01	−.002	05	.010	*W*
27	*R Pictoris*	43.5	−49 25	*Md*	+ 52	+.051	14	+.048	16	.071	*W*
28	*TT Tauri*	45.2	+28 21	*Nb*	− 38	−.050	13	+.015	14	.052	*W*
29	*V Tauri*	46.3	+17 22	*Md*	− 100	−.143	19	+.016	21	.144	*W*
30	*R Orionis*	53.6	+ 7 59	*R?*	+ 92	+.136	28	−.280	23	.314	*W*
31	*R Leporis*	55.4	−14 57	*Pec*	− 12	−.018	11	+.019	12	.026	*W*
32	*W Orionis*	5 0.2	+ 1 2	*Nb*	+ 05	+.008	08	−.017	07	.019	*W*
33	*TX Aurigæ*	2.2	+38 52	*Nb*	+ 09	+.010		−.013	. . .	.016	*N*
34	*UV Aurigæ*	15.3	+32 24	*R?*	+ 10	+.013		−.003	. . .	.013	*N*
35	*T Columbæ*	15.6	−33 49	*Md*	+ 28	+.035	10	+.035	12	.049	*W*
36	*S Aurigæ*	20.5	+34 4	*Nb*	+ 33	+.040		+.014		.042	*Y*
37	*RT Orionis*	27.8	+ 7 4	*Nb*	− 09	−.013		+.011		.017	*N*
38	*S Camelop*	30.2	+68 45	*R8*	− 176	−.096	.	−.062		.114	*N*
39	*TU Tauri*	39.1	+24 23	*Nb*	+ 02	+.003	14	+.003	10	.004	*W*
40	*Y Tauri*	39.7	+20 39	*Nb*	+ 21	+.029	14	−.007	10	.030	*W*
41	*H. D.* 38572	44.7	+30 36	*Na*	± 00	±.000	10	−.009	14	.009	*W*
42	*S Leporis*	6 4.6	−24 11	*Mc*	+ 06	+.008	05	−.023	07	.024	*B*
43	*TU Gem.*	4.7	+26 2	*Na*	− 01	−.001	05	−.010	04	.010	*B*
44	*UU Aurigæ*	29.7	+38 31	*Na*	+ 14	+.016	05	−.031	06	.035	*B*
45	*H. D.* 47883	35.7	+31 33	*Nc*	− 18	−.023	10	−.024	14	.033	*W*
46	*H. D.* 51208	51.3	−42 14	*Na*	+ 08	+.009	04	+.016	06	.018	*W*
47	*H. D.* 52432	56.1	− 3 6	*R5*	− 20	−.030	21	−.119	19	.123	*W*
48	*R Gemin.*	7 4.3	+22 51	*R?*	+ 18	+.025	11	−.008	16	.026	*W*
49	*R Can. Min.*	3.2	+10 11	*Pec*	+ 14	+.020	12	−.035	09	.040	*W*
50	*W Can. Maj.*	3.4	−11 46	*Na*	− 76	−.112	23	−.008	12	.112	*W*
51	*L_2 Puppis*	10.5	−44 28	*Md*	+ 101	+.111	04	+.327	04	.345	*W*
52	*H. D.* 58881	22.1	−14 31	*Rp*	− 05	−.007		−.003		.008	*N*
53	*H. D.* 59643	25.8	−21 44	*R8*	− 14	−.019	07	−.003	07	.019	*W*
54	*S Can. Min.*	27.3	+ 8 32	*Md*	+ 04	+.006	15	+.026	14	.027	*W*
55	*S Gemin.*	37.0	+23 41	*Md*	− 34	−.047	15	−.028	16	.055	*W*
56	*H. D.* 62164	37.5	10 39	*Mc?*	+ 03	+.004	30	+.011	21	.011	*W*
57	*T Canc.*	43.5	+23 59	*R?*	− 10	−.014	08	+.023	08	.027	*W*
58	*U Puppis*	56.2	−12 34	*Md*	− 11	−.016		−.036		.038	*Y*
59	*R Cancri*	8 11.1	+12 2	*Md*	− 53	−.078	14	+.014	12	.079	*W*
60	*RY Hydræ*	14.9	− 3 5	*Nb*	− 14	−.021	11	−.017	11	.027	*W*

	Star	α	δ	Spec.	μ_x			μ_y		μ	
61	*V Cancri* .	8 16.0	+17 36	*Md*	−.0004	−.006	±.014	+.019	±.018	.020	*W*
62	*U Cancri*	30.0	+19 14	*Md*	− 02	−.003	08	−.005	09	.006	*W*
63	*R Pyxidis* .	41.3	−27 50	*Md*	− 48	−.063	14	+.006	15	.063	*W*
64	*H. D.* 75021	42.4	−29 22	*K8*	− 30	−.039	08	−.005	09	.039	*W*
65	*S Hydræ* . .	48.4	+ 3 27	*Md*	+ 66	+.099	21	+.103	22	.143	*W*
66	*X Cancri*	49.8	+17 37	*Nb*	− 03	−.004	03	+.005	03	.006	*W*
67	*T Hydræ* . . .	50.8	− 8 46	*Md*	− 34	−.046	12	+.012	10	.048	*W*
68	*T Cancri* . .	51.0	+20 14	.	− 10	−.014	.	−.005		.015	*Y*
69	*RS Cancri*	9 4.6	+31 22	*Mc*	− 12	−.015	09	−.034	08	.037	*W*
70	*R Carinæ* .	29.7	−62 21	*Md*	− 79	−.055	03	+.012	07	.056	*W*
71	*R Leonis* . .	42.2	+11 54	*Md*	− 03	−.004	09	−.033	06	.033	*B*
72	*H. D.* 85319	45.9	− 1 33	*Nb*	− 10	−.015	14	−.026	14	.030	*W*
73	*Y Hydræ* . .	46.4	−22 32	*Np*	− 13	−.018	09	+.001	09	.018	*W*
74	*X Velorum* .	51.3	−41 7	*Nb*	− 21	−.021	09	−.025	10	.035	*W*
75	*V Leonis* . .	54.5	+21 44	*Md*	+ 15	+.021		+.010	. .	.023	*Y*
76	*S Carinæ* . . .	10 6.2	−61 4	*Md*	− 131	−.095	04	+.065	07	.115	*W*
77	*H. D.* 88539	7.5	−34 50	*Na*	− 13	−.016	06	+.015	07	.022	*W*
78	*U Antliæ*	30.8	−39 3	*Nb*	− 16	−.054	05	+.003	05	.054	*W*
79	*U Hydræ* .	32.6	−12 53	*Nb*	+ 24	+.035	09	−.015	07	.038	*B*
80	*R Urs. Maj.*	37.6	+69 18	*Md*	− 10	−.005	03	−.018	07	.019	*W*
81	*H. D.* 92839	38.1	+67 56	*Na*	− 06	−.003	03	−.004	10	.005	*W*
82	*V Hydræ* . .	46.8	−20 43	. .	− 35	−.049		+.034	. .	.060	*Y*
83	*R Crateris* .	55.6	−17 47	*Mc*	− 52	−.074	21	−.020	18	.077	*W*
84	*S Crateris* .	11 47.6	− 7 3	*Mc*	− 29	−.043	22	−.052	22	.068	*W*
85	*T Virginis* . .	12 9.5	− 5 29	*Md*	− 54	−.081	27	+.068	22	.100	*W*
86	*SS Virginis* .	20.1	+ 1 20	*Np*	+ 01	+.001	12	±.000	12	.001	*W*
87	*R Virginis* . .	33.1	+ 7 32	*Md*	− 25	−.037	03	+.006	10	.038	*W*
88	*S Urs. Maj.*	39.6	+61 38	*Pec*	− 76	−.054	13	−.010	18	.056	*W*
89	*Y Can. Ven* .	40.4	+45 59	*Nb*	+ 01	+.004	02	+.010	03	.011	*W*
90	*U Virginis* . .	46.0	+ 6 6	*Md*	+ 05	+.007	03	+.007	08	.010	*W*
91	*RY Draconis*	52.5	+66 32	*Np*	+ 08	+.005	01	−.020	11	.021	*W*
92	*SW Virginis*	13 8.9	− 2 16	*Mc*	− 44	−.062	11	−.020	10	.065	*W*
93	*V Virginis* .	22.6	− 2 39	*Md*	− 06	−.009	18	+.076	14	.077	*W*
94	*R Hydræ* . .	24.2	−22 46	*Md*	− 52	−.072	03	+.004	04	.072	*W*
95	*S Virginis*	27.8	− 6 41	*Md*	+ 07	+.010	12	−.043	12	.044	*W*
96	*T Centauri* . .	36.0	−33 5	*Md*	− 27	−.034	06	+.004	07	.034	*W*
97	*W Hydræ* .	43.4	−27 52	*Md*	− 46	−.061	06	−.058	07	.084	*W*
98	*R Centauri* .	14 9.4	−59 27	*Md*	− 46	−.035	05	−.012	09	.037	*W*
99	*RX Bootis* .	19.7	+26 11	*Mc*	+ 06	+.008	09	−.052	08	.053	*W*
100	*V Bootis* . .	25.7	+39 18	*Md*	+ 18	+.021	12	−.050	13	.054	*W*
101	*R Bootis* . . .	32.8	+27 10	*Md*	− 16	−.021	07	+.015	06	.026	*W*
102	*Lal.* 6222 . .	15 4.7	−69 42	*N*	− 07	−.004	01	−.006	04	.007	*W*
103	*S Serpentis* .	17.0	+14 40	*Md*	+ 02	+.003	13	+.017	11	.017	*W*
104	*S Coronæ* . .	17.3	+31 44	*Md*	− 09	−.011	08	−.022	09	.025	*W*
105	*U Libræ*	36.2	−20 51	. .	+ 24	+.034	.	−.014	.	.056	*Y*
106	*R Coronæ* . . .	44.4	+28 28	*Pec*	+ 03	+.001	07	−.018	06	.018	*B*
107	*V Coronæ* . . .	46.0	+39 52	*N*	+ 38	+.044	. .	+.005	.	.044	*Y*
108	*R Serpentis* .	46.1	+15 26	*Md*	− 05	−.007	12	−.048	11	.049	*W*
109	*RR Herculis* . . .	16 1.5	+50 46	*Md*	+ 33	+.031	. . .	+.005	. . .	.031	*Y*

	Star	α	δ	Spec	μ_α			μ_δ		μ	
110	*R Herculis*	16 1.7	+18 38	*Md*	+.0015	+.021	±.008	−.013	±.008	.025	W
111	*U Scorpii*	2.5	+10 12	*Md*	+ 02	+.002		+.019		.019	Y
112	*V Ophiuchi*	21.2	−12 12	*N*	+ 11	+.016		−.004		.016	*N*
113	*S Herculis*	47.1	+15 7	*Md*	− 84	−.122	36	−.028	10	.125	*W*
114	*RS Scorpii*	48.4	44 56	*Md*	+ 30	+.032	10	−.030	13	.044	*W*
115	*RR Scorpii*	50.2	−30 25	*Md*	− 11	−.018	11	−.017	12	.025	*W*
116	*R Ophiuchi*	17 2.0	−15 58	*Md*	− 35	−.050	12	−.019	11	.054	*W*
117	*V Pavonis*	34.7	−57 10	*N*	− 09	−.007	06	−.056	10	.056	*W*
118	*R Pavonis*	18 3.3	−63 38	*Md*	− 01	−.001	08	+.025	16	.025	*W*
119	*T Herculis*	5.3	+31 0	*Md*	+ 02	+.003	07	+.010	06	.010	*W*
120	*RX Scuti*	31.7	− 7 41	*N*	+ 97	+.144		+.001	.	.144	*N*
121	*R Scuti*	42.2	− 5 49	*Pec*	− 43	−.064	05	−.033	01	.072	*B*
122	*S Scuti*	44.9	− 8 1	*N*	+ 11	+.016	29	+.012	27	.020	*W*
123	*T Scuti*	50.0	− 8 18	*N*	+ 26	+.038	22	+.062	23	.073	*W*
124	*V Aquila*	59.1	− 5.50	*N*	+ 10	+.015	08	+.009	08	.018	*W*
125	*R Aquila*	19 1.6	+ 8 5	*Md*	+ 03	+.004	13	−.076	08	.076	*W*
126	*RY Sagitt.*	10.0	−33 42	*Pec*	− 07	−.009	08	+.011	08	.014	*W*
127	*W Aquila*	10.0	− 7 13	. .	± 00	±.000	. .	−.018	. .	.018	*N*
128	*B. D.* +76 734	25.1	+76 23	*N*	− 30	−.010	01	−.009	05	.013	*W*
129	*S. D.* −16 5360	28.6	−16 35	*N*	+ 20	+.029	08	−.006	08	.030	*W*
130	*R Cygni*	34.1	+49 58	*Md*	− 09	−.009	08	−.011	06	.014	*B*
131	*UW Sagitt.*	40.6	−18 24	*N*	+ 02	+.003	.	+.020	.	.020	*N*
132	*χ Cygni*	46.7	+32 40	*Mdp*	− 60	−.076	12	−.054	10	.093	*B*
133	*S Pavonis*	46.8	−59 27	*Md*	− 07	−.005	06	−.064	09	.064	*W*
134	*RS Cygni*	20 9.8	+38 28	*N*	− 10	−.012	06	−.011	07	.016	*W*
135	*T Microscop.*	21.8	−28 35	*Md*	− 04	−.005	06	±.000	05	.005	*W*
136	*Y Aquarii*	39.1	− 5 12		+ 09	+.014	.	+.035	.	.038	*Y*
137	*U Delphini*	40.9	+17 44	*Md*	+ 03	+.004	14	+.008	15	.009	*W*
138	*V Aquarii*	41.8	+ 2 4	*Md*	− 19	−.028	11	−.018	11	.033	*W*
139	*T Aquarii*	44.7	− 5 31	*Md*	− 10	−.015	22	−.035	19	.038	*W*
140	*R Vulpec.*	59.9	+23 26	*Md*	+ 12	+.017	08	−.005	07	.018	*W*
141	*T Cephei*	21 8.2	+68 5	*Md*9	− 86	−.018		−.041	.	.063	*S*
142	*T Indi*	13.6	−45 26	*N*	+ 06	+.006	08	−.004	09	.007	*W*
143	*T Capricorni*	16.5	−15 35	*Md*	+ 04	+.005		−.013	. . .	.014	*Y*
144	*YY Cygni*	18.6	+41 58		+ 18	+.020		−.024		.031	*N*
145	*W Cygni*	32.2	+44 56	*Me*	+ 73	+.078	34	+.004	27	.078	*W*
146	*S Cephei*	36.5	+78 10		+ 58	+.018		−.003	. .	.018	*N*
147	*P* 253	37.8	+35 3	*N*	− 01	−.001	09	−.006	09	.006	*W*
148	*U Aquarii*	57.9	−17 6	.	+ 01	+.001		+.020		.020	*Y*
149	*S Aquarii*	22 51.8	−20 53	*Md*	− 108	−.154	29	−.011	26	.157	*W*
150	*R Pegasi*	23 1.6	+10 0	*Md*	− 20	−.030		−.023		.038	*Y*
151	*R Aquarii*	38.6	−15 50	*Md*	− 02	−.003	06	−.006	07	.007	*B*
152	19 *Piscium*	41.3	+ 2 56	*N*	− 34	−.054	03	−.020	03	.054	*B*
153	*TZ Cassiop.*	48.0	+60 27	*Me*	− 05	−.004		−.002		.004	*N*
154	*R Cassiop.*	53.3	+50 50	*Md*	+ 64	+.061	06	−.010	09	.062	*W*

Only three stars of this list, *o Ceti*, *Md*, *L₂ Puppis*, *Md*, and *R Orionis*, *Pec.*, *R?*, have proper-motions exceeding 20″ per century and that of only one other, *S Aquarii*, *Md*, exceeds 15″ per century. The Class *N* stars appear to have systematically very small proper-motions, the four determinations resulting in motions exceeding 6″ per century being of low weight. Inasmuch as the radial motions of the few stars of this class which have

been observed are also small, it would appear that these stars as a class are among the slowest moving members of our stellar system. The mean proper-motions of the different classes of stars are:

Class	μ	No.	Wt.
Mc, Md	0.0559	80	89.7
R	.0477	13	11.5
N	.0266	46	57.8
Unclas.	.0385	15	15.9

Solutions for the coördinates of the solar motion referred to these stars give the values shown in the first two lines of Table II. The results secured by RAYMOND[3] from stars of all types, by GYLLENBERG[4] from the long period variables and by the writer from MERRILL's line of sight observations of the *Md* stars[4] are given in the last three lines of the same table. Considering the number of stars upon which most of the solutions are based the results are in good agreement.

TABLE II

A	*D*	*M*	No.	
269.8	+35.2	0.0153	154	WILSON
276.8	+26.4	.0190	80	WILSON
269.1	+32.3	.0543	5943	RAYMOND
270.9	+22.5	.0214	42	GYLLENBERG
271.2	+21.2	36.5 km.	43	MERRILL

The coördination of the solar speed derived from the radial velocities of the *Md* stars, V = 36.5 km. per sec. with the value of the parallactic motion derived from the same stars indicates a mean parallax for stars of this class,

$$\pi_m = 0''.0025$$

a value in harmony with the view that most of the brighter stars of this class are giants. In the mean, also, they must be among the most rapidly moving members of our stellar system.

A solution for the preferential motion of the 151 stars having proper-motions of less than 20″ per century gives for the directions of the axes of the velocity ellipsoid and the mean square motions along the axes.

$$A_1 = 82^\circ.2 \qquad D_1 = +18^\circ.3 \qquad \lambda_1 = 16'.06$$
$$A_2 = 250.3 \qquad D_2 = +71.3 \qquad \lambda_2 = 7.89$$
$$A_3 = 171.0 \qquad D_3 = -3.6 \qquad \lambda_3 = 9.30$$

Owing to the approximate equality of the velocities along the two minor axes, their directions in the plane normal to the direction of preferential motion are somewhat uncertain. Nevertheless, the comparison with other results given in Table III is interesting. Results are quoted for those classes of stars approaching most closely the characteristics of the stars under discussion and the final results of RAYMOND[3] and GYLLENBERG[5] for stars of all types derived by different methods. Considering the differences in material, methods and, in most cases, the small number of stars available, the accordance in the directions of the axes is fair. The apparent reversal of the axis of avoidance, noted by RAYMOND in comparing his results with those of GYLLENBERG and EDDINGTON and HARTLEY[6], appears in the results from the red stars. This may be due to any one or to a combination of a number of causes and will be made the subject of an early investigation.

[3]*Astronomical Journal*, Vol. XXX, p. 197, 1917.
[4]*Publications of the Detroit Observatory*, Vol. II, p. 62, 1916.
[5]*Meddelanden, fran Lunds Astronomiska Observatorium*, Series II, No. 13, p. 35, 1915.
[6]*Monthly Notices, R. A. S.*, Vol. LXXV, p. 521, 1915.

TABLE III

A_1	D_1	A_2	D_2	A_3	D_3	λ_2/λ_1	λ_3/λ_1	No.	Material	Method	Authority
94	+25	339	+42	205	+37	0.45	0.12	223	*M*	Proper	RAYMOND
100	8	333	77	192	−10	.52	73	157	*K*5 — *M*	Radial	EDD. & HART.
69	14	257	76	158	+ 2	.89	95	571	*K* — *M*	Radial	GYLLENBERG
82	8	250	71	171	− 4	.49	.58	154	*Md, N, R*	Proper	WILSON
80	0	348	84	170	+ 6	.80	.93	462	<5.0	Radial	GYLLENBERG
92	4	353	65	184	+25	.52	.34	5384	μ < 20″	Proper	RAYMOND
84	5	336	60	177	+30	.72	.89	1526	all	Radial	GYLLENBERG
92	17	299	71	185	+ 8	.55	.30	5943	all	Proper	RAYMOND
93	18	319	64	189	+18	.51	.34	415	all	Real	RAYMOND

CONCLUSIONS

1. The proper-motions of the Class *Md* stars are in general small, their radial motions are large; apparently, therefore, their real motions are large, they are very distant and the majority of those listed herein must be giants.

2. The proper-motions of the Class *N* stars are in general small, the radial motions of the few that have been observed are also small; they must as a class, therefore, be numbered among the more slowly moving members of the stellar system.

3. The red stars follow the general tendency of the stars of other spectral types in preferential motion toward KAPTEYN'S vertex, the velocity figure approximating an ellipsoid of revolution slightly flattened possibly toward a plane at right angles to the Milky Way.

Dudley Observatory, Jany. 18, 1922.

PARALLAXES OF THIRTY-FOUR STARS,

DETERMINED BY PHOTOGRAPHY WITH THE 26-INCH McCORMICK REFRACTOR,

By CHAS. P. OLIVIER.

Measurements of the following stars, assigned the writer by Director S. A. MITCHELL and forming part of the regular parallax program at the Leander McCormick Observatory, have recently been completed. Their relative parallaxes are given in the table below. The serial numbers follow those published in *A. J.* 778 and Vol. III, Publications of the Leander McCormick Observatory. The headings of the columns are self-explanatory.

Among the following stars are 11 components of 9 doubles. Of these *α Fornacis*, ψ^5 *Auriga*, *β* 208, Lal. 24652, Σ 2434A and Lal. 41363 show parallaxes of some size. The components of Lal. 1661–2 appear to have a common proper-motion in right ascension, and may hence be a system of the 61 *Cygni* type. *B.D.* −11°.2296, which was supposed to have a large proper-motion†, is shown to have a very small one.

† Contributions from the Mt. Wilson Observatory, No. 96.

No.	Star	R. A. 1900	Decl. 1900	Mag. and Spect.	Parallax μ	Parallax McCormick	Parallax Spect. −0″.005	Proper-motion Obs.	Proper-motion Boss
		h m	° ′		″	″ ″	″	″	″
262	*δ Andromedæ*	0 31.0	+30 19	3.5 K_2	0.162	+0.035 ± 0.008	+0.024	+0.130	+0.138
263	Lal. 1661	0 53.2	−16 13	7.		+0.006 ± 0.009		+0.071	
264	Lal. 1662	0 53.2	−16 13	7.2		+0.021 ± 0.012		+0.072	
265	Boss 556	2 22.1	+ 9 15	6.5 G_0	0.355	+0.022 ± 0.009	+0.024	+0.303	+0.291
266	*α Fornacis*	3 7.8	−29 23	4.0 F_8	0.726	+0.080 ± 0.007	+0.078	+0.267	+0.327
267	*W.B.* 6^h, 128	6 9.6	+11 15	8.6 K_0	0.44	+0.024 ± 0.007	+0.031	+0.270	+0.245*x*
268	ψ^5 *Auriga*	6 39.5	+43 41	5.3 G_0	0.158	+0.048 ± 0.008	+0.058	+0.024	+0.007
269	Lal. 13849	7 4.2	+21 25	6.5 G_5	0.510	+0.020 ± 0.007	+0.037	−0.168	−0.168*x*
270	*W.B.* 8^h, 181	8 12.0	+30 56	8.6 K_5	0.873	+0.015 ± 0.008	+0.047	−0.315	−0.292*x*
271	*B.D.* −11°.2296	8 11.5	−11 27	9.3	[0.72]	+0.001 ± 0.007		−0.022	
272	*B.D.* −11°.2299	8 11.7	−11 31	9.1		−0.018 ± 0.008 −0.015 ± 0.007	. .	+0.001 +0.003	*a*
273	*B.D.* −11°.2300	8 11.7	−11 27	9.3 K_5		−0.007 ± 0.009 0.002 ± 0.009		−0.030 −0.030	*a*
274	*B.D.* −11°.2301	8 11.7	−11 32	9.9 F_5	.	−0.010 ± 0.007	.	+0.018	
275	*β* 208	8 31.8	−22 19	5.1 G_5	0.178	+0.047 ± 0.008	+0.030	−0.249	−0.236*xd*
276	83 *Cancri*	9 13.1	+18 8	6.6 F_5	0.180	+0.019 ± 0.010	+0.019	−0.116	−0.115
277	*κ Leonis*	9 18.8	+26 37	4.6 K_0	0.061	−0.007 ± 0.011	+0.017	−0.008	−0.031
278	Lal. 24652	13 11.9	+17 31	6.6 K_0	0.691	+0.062 ± 0.007	+0.080	+0.637	+0.637*xc*
279	*θ Bootis*	14 21.8	+52 19	4.1 F_8	0.471	+0.067 ± 0.009	+0.055	−0.261	−0.238
280	*τ Coronæ Bor.*	16 5.3	+36 45	4.9 K_0	0.325	+0.029 ± 0.012	+0.033	−0.029	−0.060
281	12 *Ophiuchi*	16 31.1	− 2 7	5.9 K_0	0.516	+0.019 ± 0.007	+0.082	+0.476	+0.444
282	*W.B.* 16^h, 906	16 50.1	− 8 9	9.2 Md	1.231	+0.118 ± 0.011	+0.116	−0.815	−0.858*x*
283	*A.Oe.* 17415	17 37.0	+68 26	9.5 Mb	1.331	+0.193 ± 0.005	+0.153	−0.384	−0.376*x*
284	*A.Oe.* 17419 . .	17 37.2	+68 27	8.0 F_2	. . . .	−0.023 ± 0.006	+0.003	−0.023	. . . . . .

No.	Star	R.A. 1900	Decl. 1900	Mag. and Spect.	μ	Parallax McCormick	Parallax Spect. $-0''.005$	Proper-motion Obs.	Proper-motion Boss
		h m	° ′		″	″ ″	″	″	″
285	*Nova Aquilæ* 3 . .	18 43.8	+ 0 28		. . . .	-0.008 ± 0.007	. . . . .	-0.018	. . . . . .
286	Σ 2434 *A*	18 57.6	− 0 51	7.9	0.14	$+0.051 \pm 0.006$	. . .	-0.026	. .
287	*B*	18 57.6	− 0 51	8.4		$+0.006 \pm 0.011$	. . . . .	$+0.030$	. .
288	3 *Cygni*	19 21.3	+24 44	6.2 F_6	0.658	$+0.023 \pm 0.010$	$+0.030$	-0.226	-0.186
289	γ *Sagittæ* . . .	19 54.3	+19 13	3.7 K_6	0.062	$+0.014 \pm 0.007$	$+0.018$	$+0.056$	$+0.060$
290	ε *Delphini* . .	20 28.4	+10 58	4.1 B[illegible]	0.028	-0.009 ± 0.008	. . . . . .	-0.004	$+0.009$
291	ε *Aquarii* .	20 42.2	− 9 52	3.8 A_0	0.044	$+0.018 \pm 0.009$	. . .	$+0.046$	$+0.028$
292	*T Vulpeculæ*	20 47.2	+27 53	5.8 F_9	0.015	$+0.015 \pm 0.007$	-0.002	$+0.027$	+0.[illegible]
293	Lal. 41363 .	21 11.0	−26 46	6.6 G_8	0.665	$+0.041 \pm 0.009$	$+0.058$	-0.574	−0.[illegible]
294	*W.B.* 21^h, 502	21 24.5	−12 56	9.4 K_6	1.052	$+0.034 \pm 0.010$	$+0.061$	$+0.990$	+1.0[illegible]
295	Boss 5920	22 53.5	+ 8 50	7.0 G_0	0.420	$+0.003 \pm 0.011$	$+0.023$	$+0.381$	+0.39[illegible]

a Two solutions made, 2 comparison stars being changed.
b Partly measured by Miss DARKOW.
c Partly measured by Miss HAWES.
x Proper-motion according to PORTER.

Leander McCormick Observatory, University, Va.,
Jan. 6, 1922.

ON ABERRATION AND PARALLAX IN ORBIT COMPUTATION,

BY ERNEST CLARE BOWER.

[Communicated by Captain W. D. MACDOUGALL, U. S. Navy, Superintendent of U. S. Naval Observatory.]

The annual aberration and geocentric parallax may be more expeditiously handled in orbit work than is commonly done. Let axes be referred to the mean equator and equinox at beginning of year in the usual way. Let

$x\ ,\ y\ ,\ z$ = heliocentric coördinates of object at true time (observed time — light time),

$X_E,\ Y_E,\ Z_E$ = geocentric coördinates of *Sun* at observed time,

$\Delta X,\ \Delta Y,\ \Delta Z$ = observer's coördinates of center of *Earth* at observed time, in same system and units.

Then if $\rho,\ \alpha,\ \delta$ are derived from

$$\begin{aligned} \rho \cos\delta \cos\alpha &= x + X_E + \Delta X \\ \rho \cos\delta \sin\alpha &= y + Y_E + \Delta Y \\ \rho \sin\delta \quad\quad &= z + Z_E + \Delta Z \end{aligned}$$

ρ is the distance over which, and $\alpha,\ \delta$, the direction from which, light came from the object to the observer. This $\alpha,\ \delta$, is called "astrographic" (Greenwich Observations **1910**, and following), and is the position obtained by using mean places of the comparison stars in reducing a photographic plate, or by applying $\Delta\alpha$ and $\Delta\delta$ directly to the mean place of the comparison star in a visual observation. However, in the latter case, the $\Delta\alpha$ and $\Delta\delta$ given are apparent and for greater accuracy should be corrected for differential precession, nutation, and aberration, but this is usually negligible.

This treatment has certain advantages and apparently no disadvantages. (a) It is not peculiar to any orbit method. (b) The annual aberration is fully taken into account (Poincaré, B. A. **1906**, 174 and Lick Obs. Pub. **7**, 246). (c) In preliminary orbits, where the *Sun's* coördinates are interpolated for the true time, this time is often not well enough known to avoid more than one interpolation, but here the *Sun's* coördinates are computed but once in any case. (d) The reduction to apparent place of the comparison star by the observer in visual observations, and the reduction to mean place of the object by the orbit computer, are both eliminated. (e) The computation of the parallax factors is omitted. In its place we have (Chauvenet, Spherical and Practical Astronomy, Vol. 1, 120, and others)

$$\begin{aligned} \Delta X &= A \cos\theta \\ \Delta Y &= A \sin\theta \\ \Delta Z &= D \end{aligned}$$

where

$$\begin{aligned} A &= [2.86166n]\ (\rho_E\ \pi \cos\varphi')^s \\ D &= [1.68557n]\ (\rho_E\ \pi \sin\varphi')'' \\ \theta &= \text{local sidereal time of observation.} \end{aligned}$$

A ... D are constants for each observatory in units of 7th place. Precession in ΔX, ΔY, ΔZ will not amount to .0000 005 in 50 years. (f) In preliminary orbits, the distance is occasionally so imperfectly known that the parallax in α and δ changes, but ΔX, ΔY, ΔZ are obtained but once in any case.

It is desired to point out again that no real use is being made of the reduction to apparent place of the comparison star as ordinarily published with visual observations. If great accuracy is wanted a differential reduction to mean place is shorter than a single reduction to mean or apparent place (*A. N.* **160**, 274; *Union Obs. Circ.* **1**, 83, 86; *A. J.* **32**, 18, 93).

U. S. Naval Observatory, Washington, D. C.,
1922, Jan. 12.

OBSERVATIONS OF ECLIPSES OF SATELLITES OF *JUPITER*, 1921,

WITH THE 26-INCH AND 12-INCH REFRACTORS OF THE U. S. NAVAL OBSERVATORY,

By ASAPH HALL AND ERNEST CLARE BOWER.

[Communicated by Captain W. D. MacDougall, U. S. Navy, Superintendent.]

G. M. T.		Phen.	Seeing	Inst.	Power	Obs.	Remarks
							Satellite I
1921	h m s						
Jan. 16	23 15 39	D	vp	26	183	HL	Late 0s.5. Windy.
18	17 13 18	D	f	26	183	HL	Uncertain. Clouds.
18	17 13 11	D	f	12	85	B	Late 1s ± ½s. Clouds.
Feb. 24	21 39 16	D	f	26	183	HL	Disappearance close to limb of planet.
Mar. 23	12 59 52	R	p	26	183	HL	Late perhaps 2s. Probably haze. Clouded immediately.
23	12 59 41	R	p	12	85	B	Late 3s ± 1s. Clouds? Haze.
28	20 25 29	R	p	26	183	HL	Eye and ear. Windy. Clouds.
28	20 25 41	R	vp	12		B	Late 5s ± 2s. Haze.
Apr. 6	16 18 40	R	g	26	183	HL	Haze.
May 8	13 25 31	R	f	26	183	HL	Late 1s.
							Satellite II
1921							
Jan. 18	21 6 27	D	f	26	183	HL	
18	21 6 8	D	f	12	85	B	Late 1s. Perhaps still visible 8s ± later.
Feb. 12	18 11 35	D	p	26	183	HL	Perhaps early 2s.
12	18 11 32	D	p	12	85	B	Late 1s. Suspected still visible 8s later.
Mar. 27	12 32 52	R	p	26	183	HL	Late. Haze.

Phen. D = disappearance of last speck of light, R = reappearance of first speck of light.
Seeing g = good, f = fair, p = poor, vp = very poor.

U. S. Naval Observatory, Washington, D. C.,
1921, Dec. 19.

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Editor Benjamin Boss, Albany, N. Y.; Associate Editors E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward.
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THE

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THE PARALLAXES OF FIFTY-SEVEN STARS.

By MILDRED BOOTH and FRANK SCHLESINGER.

The determination of these parallaxes was carried out through the coöperation of several institutions. The photographic plates were secured at Allegheny Observatory. They were measured and reduced at Yale Observatory under a grant from the National Research Council to the Committee on Stellar Parallaxes of the American Astronomical Society. The measuring engine was purchased several years ago by a grant from the Draper Fund of the National Academy of Sciences. This paper gives merely a summary of the results: the full details are in press as a Memoir of the National Academy of Sciences.

The measurements and computations were performed by Miss Booth. The average number of plates for each region is fifteen, the average number of comparison stars is 3.8, and the average probable error of a parallax is ″.0084. This last quantity is very satisfactory in view of the fact that almost every object in the list is one of more than average difficulty, either because the star is double or for some other reason.

The number assigned to these stars (470-526) are in continuation of those assigned to other parallaxes determined from Allegheny plates.

No.	Name	α 1900	δ 1900	Durchmusterung Number	Visual Magnitude and Spectrum	Total Proper-Motion	Relative Parallax and Probable Error	
		h m				″	″	″
470	Σ 16	0 11	+54 6	53 31	7.5 A3	.17	+.012	±.009
471	10 *Arietis*	1 58	+25 27	25 341	5.7 F5	.14	+.021	10
472	9 *H Camelopardis*	3 49	+60 49	60 768	5.0 K0	.017	+.010	10
473	55 *Tauri*	4 14	+16 17	16 579	6.9 G0	.10	+.013	6
474	OΣ 82	4 17	+14 49	14 690	7.4 G0	.10	+.028	7
475	*Piazzi* 256	5 48	+31 41	31 1139	5.8 A3	.20	+.021	5
476	74 *Orionis*	6 11	+12 18	12 1081	5.1 F5	.21	+.039	6
477	*Groombridge* 1214	6 37	+40 14	40 1696	6.9 Ma	.17	+.005	7
478	θ *Geminorum*	6 46	+34 5	34 1481	3.6 A2	.05	+.021	9
479	15 *Lyncis*	6 49	+58 33	58 982	4.5 G5	.13	+.005	6
480	*Lalande* 15394	7 49	+19 31	19 1869	7.9 K2	.47	+.031	8
481	7 *Sextantis*	9 47	+ 2 55	3 2280	5.9 A0	.20	+.003	9
482	ζ *Leonis*	10 11	+23 55	24 2209	3.6 F0	.027	+.006	7
483	γ¹ *Leonis*	10 14	+20 21	.....	2.6	.34	+.004	11
484	γ² *Leonis*	10 14	+20 21		3.8	.35	+.018	14
	Mean			20 2467	K0		+.009	9
485	88 *Leonis*	11 27	+14 55	15 2345	6.2 G0	.38	+.026	7
486	*Lalande* 21947	11 29	+37 22	37 2195	6.3 K0	.18	−.019	12
487	61 *Ursa Majoris*	11 36	+34 46	35 2270	5.5 G5	.39	+.105	8

No.	Name	α 1900	δ 1900	Durchmusterung Number	Visual Magnitude and Spectrum	Total Proper-Motion	Relative Parallax and Probable Error	
		h m	° ′	°		″	″	″
488	11 [illegible]	15 0	+18 3		6.1		+.073	±.009
489	11 [illegible]	15 0	+18 3		5.3		+.078	9
	Mean			18 2259	G0	.41	+.075	6
490	[illegible]	15 39	+2 50	2 2989	7.8 K0	.47	+.013	8
491	Σ 2052	16 24	+18 37	18 3182	7.1 K3	.51	+.050	8
492	D[illegible]	17 3	+54 36		5.8	.44	+.029	13
493	D[illegible]	17 3	+54 36		5.8	.44	+.050	13
	Mean			54 1857	F5		+.039	9
494	Lalande 34496	18 31	+34 20	34 3239	7.8 F8	.27	−.005	8
495	Weisse 1339	18 45	+34 25	34 3326	8.4 F5	.22	−.004	9
496	11 Aquilae	18 54	+13 29	13 3841	5.1 A0	.12	+.031	9
497	Σ 2481 B	19 8	+38 37		8.2		+.013	6
498	Σ 2481 A	19 8	+38 37		8.2		−.020	8
	Mean			38 3466	7.5 G5	.27	−.002	5
499	Piazzi 233	19 35	+49 3	48 2922	6.5 G0	.44	+.003	6
500	o Aquilae	19 46	+10 10	10 4073	5.2 F5	.28	+.016	10
501	Piazzi 306	19 47	+11 23	11 4019	6.2 K0	.46	+.021	10
502	OΣ 389	19 48	+30 53	30 3779	6.9 A5	.00:	+.024	8
503	Weisse 1190	19 49	+1 41	1 4134	8.5 K0	.30	+.018	11
504	Weisse 1196	19 49	+1 41	1 4135	8.8 K0	.29	+.019	15
505	η Cygni	19 53	+34 49	34 3798	4.0 K0	.05	+.007	5
506	27 Cygni	20 3	+35 42	35 3959	5.5 K0	.49	+.022	6
507	Lalande 38613	20 5	+16 30	16 4166	7.7 K0	.47	+.015	7
508	Groombridge 3150	20 17	+66 32	66 1281	6.4 G0	.56	+.050	7
509	1 Delphini	20 26	+10 34	10 4303	5.9 A0	.020	−.005	11
510	κ Delphini	20 34	+9 44	9 4600	5.2 G2	.32	+.014	9
511	γ¹ Delphini	20 42	+15 46		5.5	.20	+.019	6
512	γ² Delphini	20 42	+15 46		4.5	.21	+.021	5
	Mean			15 4255	G5		+.020	4
513	OΣ 447	21 36	+44 46	44 4224	8.1 K0		.000	8
514	OΣ 447	21 36	+44 46	44 4225	8.7 K0		−.002	5
	Mean					.00:	−.001	4
515	OΣ App. 226	21 51	+67 38	67 1370	9.6 A		−.005	9
516	OΣ App. 226	21 51	+67 38	67 1372	7.6 K0		−.019	7
	Mean					.05	−.014	5
517	Lalande 43751	22 19	+38 4	37 4560	6.2 G0	.29	−.013	6
518	Fedorenko 1220	22 34	+72 22	72 1050	7.5 F5	.10	+.031	10
519	Fedorenko 1222	22 34	+72 21	72 1051	8.3 G	.09	+.032	9
	Mean						+.033	7
520	OΣ 478	22 40	+38 56	38 4855	6.4 K4	.016	+.003	6
521	[illegible] Pegasi	22 47	+9 18	9 5122	5.3 F0	.52	+.028	9
522	π Cephei	23 5	+74 51	74 1006	4.6 G5	.030	+.003	8
523	70 Pegasi	23 24	+12 13	11 5009	4.7 K0	.06	−.011	9
524	72 Pegasi	23 29	+30 46	30 4978	5.2 K0	.06	+.003	11
525	λ Piscium	23 37	+1 11	0 5037	4.6 A5	.20	+.027	12
526	Anonymous	23 37	+1 7	....	10: ..	.19	+.018	9

A NEW MEMBER OF THE *TAURUS* CLUSTER.

By GEORGE C. COMSTOCK.

The *Taurus* moving cluster, first discussed by L. Boss and subsequently much amended by others, contains one feature that persists through all of these discussions, *viz.*, the small range of magnitude among the stars considered. In the most recent of these discussions Rasmuson, Lund. Meddelanden, Series II, No. 26, the adopted magnitudes (Harvard) for 42 stars are included between the limits 3.62 and 6.39. The additional faint member of the cluster proposed below is of interest in that it considerably increases this range of magnitude and intrinsic luminosity.

I have shown in Publications of the Washburn Observatory Vol. XII, p. 216, that a faint companion of *α Tauri* possesses a considerable proper-motion and more recently I have revised that determination with added and improved data, micrometer comparisons with *α Tauri*, and find for the centennial motion of the star in question, referred to the Boss system, *P. G. C.*,

$$\mu_A = +10''.0 \pm 0''.21,\ \mu_D = -4''.0 \pm 0''.21,$$

or in polar coördinates,

$$\theta = 111^\circ.8 \pm 1^\circ.2,\ s = 10''.7 \pm 0''.2.$$

The position of the star in question is

$$\alpha = 4^h\,30^m\,15^s,\ \delta = +16^\circ\,20'.1$$

(1900.0) and its photometric magnitude (*Harvard Annals* 64, 167) is 10.59. I am advised by Director SHAPLEY that the Harvard photographic magnitude of the star indicates a color index of 0.6 or more.

Adopting RASMUSON's determinations of the convergent point for the cluster, its mean parallax and linear speed relative to the *Sun*, *viz.*, $A = 93^\circ.2$, $D = +7^\circ.0$, $\pi = 0''.0275$, $\Omega = 44.2$ km sec, I find that a member of the cluster situated at the point α, δ, above given should show a proper-motion defined by the elements, $\theta = 107^\circ.4$, $s = 10''.70$. The relation employed in deriving s from the elements above defined is

$$s = [1.324]\,\pi\,\Omega \sin\lambda$$

where λ denotes the angular distance of the star from the convergent, in this case $26^\circ.5$. The discordance between the observed and the computed values of θ and s falls well within what might be expected from the character of the data involved, and their approximate agreement, together with the circumstance that the star is placed almost at the visible center of the cluster seem to leave little doubt of a physical connection. The range of luminosities within the group must therefore be increased from 2.8^m to 7.0^m *i. e.* from a 13-fold to a 600-fold ratio of the brightest to the faintest star yet detected.

Details of the determination of this proper-motion are contained in Vol. XIV, Publications of the Washburn Observatory, now in press.

Washburn Observatory,
January, 1922.

OBSERVATIONS DE PLANÈTES ET DE LA COMÈTE *TEMPEL* II (1920*a*),

FAITES À L'OBSERVATOIRE DE BESANÇON, EQUATORIAL COUDÉ DE $0^m.33$ d'ouverture,

PAR M. P. CHOFARDET.

Date	T. m. Besançon	ΔA.R.	ΔD.P.	Cp.	A.R. app	log f.p	D.P. app.	log f.p.	Réd. au j.		*
					(3) *Juno*						
1920	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Juin 7	10 23 14	+2 58.91	+ 2 2.2	9,12	13 54 45.86	9.197	88 7 29.4	0.798*n*	+2.89	+ 9.8	1
					(8) *Flora*						
Févr. 19	9 34 20	−0 53.12	+ 4 53.7	9, 6	6 16 20.00	9.134	65 39 30.2	0.548*n*	+2.39	+ 6.3	2
23	8 54 1	+1 24.10	+ 2 54.4	9, 6	6 17 57.16	8.942	65 30 9.4	0.536*n*	+2.33	+ 6.2	3
24	8 48 48	+1 53.43	+ 0 43.5	9,12	6 18 26.17	8.921	65 27 58.5	0.535*n*	+2.31	+ 6.2	3
25	9 16 6	+2 25.50	− 1 25.5	9,12	6 18 58.53	9.151	65 25 49.4	0.535*n*	+2.30	+ 6.1	3
					(10) *Hygeia*						
Janv. 22	10 11 19	+1 8.69	−13 6.2	9, 6	4 42 19.61	9.238	66 0 35.1	0.563*n*	+2.30	+ 1.1	4
23	10 59.47	+2 30.40	− 1 36.0	9,12	4 12 3.90	9.415	66 2 15.1	0.595*n*	+2.28	+ 0.9	5
24	10 40 25	+2 16.75	− 0 4.0	9,12	4 11 50.21	9.374	66 3 47.1	0.586*n*	+2.27	+ 0.9	5

Dates	T. m. Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log. f.p.	Réd. au j.		*
					(10) *Hygiea* (*Continued*)						
	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Févr. 16	8 46 19	+1 15.06	−1 22.5	9, 6	1 12 19.58	9.289	66 26 50.2	0.476*n*	+1.95	+ 1.4	6
18	9 32 16	+1 53.49	−0 29.2	9, 9	1 13 27.98	9.448	66 27 13.5	0.610*n*	+1.92	+ 1.4	6
19	8 57 22	+2 13.97	−0 8.3	9, 9	1 13 18.44	9.363	66 28 4.5	0.590*n*	+1.90	+ 1.5	6
					(30) *Urania*						
Nov. 9	12 20 48	+2 13.42	−5 58.8	9,12	2 10 9.43	9.013	70 43 23.3	0.614*n*	+5.00	−17.9	7
Déc. 13	6 36 55	+1 4.78	−11 45.2	9, 6	2 19 13.91	9.366*n*	72 33 52.2	0.669*n*	+1.87	−19.8	8
14	6 59 29	+1 1.47	−9 38.1	9, 6	2 19 10.59	9.281*n*	72 35 59.4	0.659*n*	+1.86	−19.7	8
					(44) *Nysa*						
Janv. 23	9 52 15	−0 10.95	+ 3 52.0	9, 6	3 3 0.55	9.458	76 51 48.0	0.726*n*	+1.60	− 0.8	9
24	9 19 57	−0 10.61	+ 3 29.1	9, 6	3 3 48.61	9.394	76 48 55.0	0.715*n*	+1.59	− 0.6	10
Févr. 18	8 47 40	−3 33.47	+ 7 11.1	9,12	3 34 57.19	9.480	74 1 7.6	0.705*n*	+1.43	+ 1.0	11
19	8 27 13	−2 10.86	− 0 16.2	9, 9	3 33 19.78	9.443	73 53 10.0	0.698*n*	+1.41	+ 1.0	11
					(51) *Nemausa*						
Mai 10	10 23 6	+0 21.94	+ 3 46.3	8, 6	12 51 59.07	8.892	86 14 5.6	0.783*n*	+2.76	+14.3	12
Juin 7	11 4 17	+3 27.59	+ 5 21.7	9,12	12 55 1.52	9.477	86 15 11.8	0.791*n*	+2.56	+12.1	12
8	10 30 34	+3 51.79	+ 8 41.5	9,12	12 55 31.72	9.419	86 18 58.5	0.789*n*	+2.56	+12.0	12
10	10 13 15	+0 39.10	− 1 21.1	9, 6	12 56 34.00	9.459	86 25 54.0	0.790*n*	+2.57	+11.7	13
11	10 39 13	+1 14.90	− 0 34.2	9, 6	12 57 6.80	9.458	86 29 10.8	0.794*n*	+2.57	+11.6	13
					(56) *Melete*						
Oct. 5	10 23 55	−2 14.89	− 1 17.4	9, 9	1 12 36.64	9.277*n*	82 51 11.2	0.760*n*	+4.32	−23.8	14
13	10 47 45	−0 46.38	− 1 1.5	9, 6	1 5 55.	8.937*n*	84 9 10.	0.766*n*	+4.35	−24.5	15
Nov. 9	10 39 28	+2 9.90	−11 32.6	6, 8	0 49 11.84	9.053	87 26 24.7	0.792*n*	+4.25	−24.8	16
					(69) *Hesperia*						
Nov. 9	9 42 10	−2 37.31	+ 1 48.9	6, 8	22 5 18.47	9.410	98 25 54.3	0.848*n*	+3.19	−24.5	17
					(76) *Freia*						
Janv. 23	10 20 55	+1 33.21	+ 5 19.8	9, 6	3 29 29.00	9.472	72 14 38.2	0.690*n*	+1.80	− 1.0	18
24	10 13 22	+1 56.68	+ 3 51.8	9, 6	3 29 52.46	9.464	72 43 10.2	0.688*n*	+1.79	− 1.0	18
					(79) *Eurynome*						
Oct. 20	13 1 11	+2 58.77	+ 3 5.0	9,12	21 15 30.18	8.482*n*	98 2 6.8	0.860*n*	+3.77	−21.6	19
					(91) *Aegina*						
Oct. 1	10 31 3	+2 2.67	11 44.2	9,12	0 25 20.81	9.025*n*	87 25 31.2	0.792*n*	+1.22	−26.5	20
5	9 43 17	+4 11.22	7 12.7	9,12	0 24 29.37	9.246*n*	87 30 2.7	0.794*n*	+1.23	−26.5	20
8	11 3 52	+2 12.25	− 2 36.1	9, 9	0 21 18.50	8.179*n*	87 14 10.9	0.791*n*	+1.23	−26.7	21
13	10 19 58	+1 8.76	− 1 16.1	9, 9	0 17 37.58	8.701*n*	88 6 1.2	0.797*n*	+1.22	−26.8	22
15	10 9 5	+1 13.82	+ 6 39.1	9, 9	0 16 2.20	8.726*n*	88 14 20.6	0.798*n*	+1.22	−26.7	23
					(97) *Clotho*						
Févr. 16	10 28 58	−1 2.89	+ 8 1.7	9, 6	8 31 57.31	8.562*n*	79 50 20.9	0.724*n*	+2.51	+15.3	24
18	10 16 50	0 10.97	−12 10.5	9, 6	8 30 43.51	8.621*n*	79 30 8.8	0.721*n*	+2.57	+15.4	21
19	10 21 16	1 58.72	− 7 8.9	9, 9	8 30 8.43	8.396*n*	79 20 4.9	0.722*n*	+2.57	+15.5	25

Dates	T. m. Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log f.p.	Réd. au j.		*
					(416) *Sirona*						
1920	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Juin 8	11 0 16	−2 23.18	+ 1 45.7	9, 12	14 1 16.00	9.332	100 48 17.6	0.864*n*	+3.15	+12.4	26
10	11 22 18	+1 17.24	− 3 16.7	9, 6	14 0 57.99	9.413	100 50 15.5	0.858*n*	+3.12	+12.6	27
11	11 2 55	+1 10.52	− 2 7.0	9, 6	14 0 51.26	9.375	100 51 25.1	0.862*n*	+3.11	+12.5	27
14	11 6 18	+0 59.41	+ 2 7.8	9, 6	14 0 40.14	9.443	100 55 39.8	0.859*n*	+3.10	+12.1	27
					(173) *Ino*						
Févr. 19	10 56 1	−0 34.37	− 2 0.2	9, 6	8 36 22.61	8.394	76 29 7.0	0.694*n*	+2.60	+15.2	28
23	9 37 22	+1 59.57	+ 2 52.8	9, 6	8 33 46.53	8.922*n*	75 59 50.4	0.685*n*	+2.59	+15.0	29
24	9 14 53	+1 23.61	− 4 14.5	9, 6	8 33 10.56	9.060*n*	75 52 43.1	0.686*n*	+2.58	+15.0	29
25	9 38 50	+0 47.49	−11 28.6	9, 6	8 32 34.84	8.814*n*	75 45 29.0	0.681*n*	+2.58	+15.0	29
					(190) *Ismene*						
Févr. 24	9 52 18	+2 59.23	+ 3 59.5	9, 12	10 14 32.90	9.333*n*	82 44 18.8	0.761*n*	+2.61	+17.6	30
25	10 7 1	+2 20.72	− 1 9.0	9, 12	10 13 54.40	9.268*n*	82 39 40.4	0.758*n*	+2.62	+17.7	30
					(192) *Nausicaa*						
Mars 20	9 46 46	−1 23.48	+ 3 32.9	9, 6	10 50 34.05	9.092*n*	83 27 5.7	0.761*n*	+2.66	+18.4	31
22	10 43 1	−3 7.44	− 4 14.5	9, 12	10 48 47.08	8.794*n*	83 19 18.2	0.758*n*	+2.65	+18.3	31
					(203) *Pompeja*						
Nov. 9	14 50 27	+0 17.37	− 6 2.2	6, 6	2 29 42.99	8.822	70 45 7.4	0.617*n*	+4.97	−18.5	32
17	12 0 26	+0 53.60	−10 56.4	9, 6	2 22 14.75	9.486	71 15 58.1	0.633*n*	+4.96	−19.5	33
Déc. 14	6 32 13	−1 58.88	+ 9 2.6	9, 9	2 9 6.18	9.337*n*	72 35 56.3	0.665*n*	+4.82	−20.5	34
					(221) *Eos*						
Juin 14	10 32 15	−0 25.64	− 6 43.2	12, 9	16 25 19.81	8.585*n*	96 9 2.3	0.850*n*	+3.54	+0.5	35
					(308) *Polyxo*						
Oct. 8	10 35 17	+1 32.15	−7 57.4	9, 9	0 41 31.74	8.676*n*	89 26 10.0	0.807*n*	+4.20	−26.9	36
					(385) *Ilmatar*						
Oct. 8	9 57 33	+1 34.49	+ 4 44.9	9, 6	23 24 24.38	8.494*n*	88 48 14.8	0.802*n*	+4.08	−28.3	37
13	9 38 1	+2 31.84	+ 8 33.8	6, 8	23 20 56.56	8.400*n*	88 57 49.4	0.803*n*	+4.07	−28.3	38
15	9 25 33	+1 17.43	+11 56.7	9, 6	23 19 41.84	8.489*n*	89 1 12.3	0.804*n*	+4.06	−28.3	38
Nov. 9	10 44 57	−0 40.04	+ 8 41.0	9, 6	23 10 57.01	9.351	89 15 21.2	0.806*n*	+3.80	−27.6	39
					(485) *Genua*						
Mai 10	10 53 28	−1 6.06	−8 41.8	9, 12	13 21 7.62	8.903	92 24 20.3	0.827*n*	+2.95	+14.2	40
					(487) *Venetia*						
Nov. 9	11 12 46	+5 7.37	− 8 26.1	9, 8	0 27 14.36	9.346	103 22 22.9	0.875*n*	+4.00	−22.2	41
					(554) *Peraga*						
Mai 10	9 40 39	+2 33.63	− 7 25.8	9, 12	14 5 59.51	9.260	88 12 35.5	0.798*n*	+2.34	+17.6	42
11	9 30 48	+2 49.90	− 6 48.8	3, 4	14 6 15.77	9.235	88 13 12.5	0.798*n*	+2.30	+17.6	42
					(690) *Wratislavia*						
Déc. 14	5 59.20	+2 22 28	+ 4 33.7	9, 12	0 22 9.98	9.953*n*	77 18 29.4	0.700*n*	+3.95	−27.5	43

Date	T. m. Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log f.p.	Réd. au j.		✱
					(925) *Alphonsina*						
	h m s	m s			h m s		° ′ ″		s	″	
Mars 20	9 7 25	2 26.60	+ 1 17.7	9.12	7 25 21.41	9.221	71 26 12.3	0.677n	+2.06	+11.8	44
22	9 21 56	1 50.97	− 6 1.6	9. 6	7 26 7.12	9.315	71 37 41.7	0.682n	+2.03	+11.9	45
					Comète 1902 *a* (périodique *Tempel II*)						
Juil. 20	13 46 50	2 20.82	6 35.8	9. 6	1 52 15.75	9.553n	91 16 55.1	0.815n	+2.38	−15.0	46
20	14 25 14	2 17.44	6 30.8	9. 6	1 52 19.43	9.507n	91 17 0.4	0.816n	+2.38	−15.0	46
21	14 6 20	2 7.10	+ 2 19.7	9. 6	1 55 11.83	9.530n	91 18 51.4	0.815n	+2.40	−15.0	47

Positions des étoiles de Comparaison pour 1920.0

★	A. R. moy.	D. P. app.	Autorités		★	A. R. moy.	D. P. app.	Autorités	
	h m s	° ′ ″				h m s	° ′ ″		
1	13 54 14.06	88 5 47.1	*A. G. Albany*	4822	25	8 32 4.58	79 26 58.3	*A. G. Leipzig I*	3470
2	6 17 10.73	65 37 30.2	rap. à étoile 3		26	14 3 36.03	100 46 19.5	*A. G. Harvard*	4984
3	6 46 30.73	65 27 8.8	*A. G. Berlin B.*	2323	27	13 59 37.63	100 53 19.6	*A. G. Harvard*	4964
4	1 44 8.62	66 13 40.2	rap. à étoile 5		28	8 36 51.41	76 30 52.0	*A. G. Leipzig I*	3505
5	1 39 31.22	66 3 50.2	*A. G. Berlin B.*	1509	29	8 34 44.37	75 56 42.6	*A. G. Leipzig I*	3466
6	1 44 32.57	66 28 11.3	*A. G. Berlin B.*	1515	30	10 11 31.06	82 40 31.7	*A. G. Leipzig II*	5410
7	2 37 51.01	70 19 10.0	*A. G. Berlin A.*	729	31	10 51 51.87	83 23 14.4	*A. G. Leipzig II*	5632
8	2 18 31.26	72 45 57.2	*A. G. Berlin A.*	659	32	2 29 20.65	70 51 28.1	rap à étoile *A. G. Berlin A*	692
9	3 2 18.00	76 50 56.8	rap. à étoile 10		33	2 21 16.19	71 27 11.0	*A. G. Berlin A*	673
10	3 3 57.69	76 15 26.5	*A. G. Leipzig I*	936	34	2 14 0.24	72 27 14.2	*A. G. Berlin A.*	629
11	3 35 29.23	73 53 55.2	*A. G. Berlin A.*	985	35	16 26 11.91	96 15 45.0	*Abbadia*	5115
12	12 51 34.37	86 10 5.0	*δ Vierge*		36	0 9 55.39	89 34 34.0	*A. G. Nicolajew.*	22
13	12 55 52.33	86 30 3.4	*A. G. Albany*	1644	37	23 22 42.81	88 44 28.2	*A. G. Albany*	8077
14	1 14 17.21	82 59 25.1	*A. G. Leipzig II*	465	38	23 18 20.65	88 49 43.9	rap. à étoile 37	
15	1 6 37	84 10 39	*B. D.* + 5	151	39	23 14 33.22	89 7 37.8	*A. G. Nicolajew*	5798
16	0 46 57.69	87 11 22.1	*A. G. Albany*	216	40	13 25 10.73	92 32 50.9	*A. G. Strasbourg*	4859
17	22 8 22.32	98 21 29.9	*A. G. Wien-Ottak.*	7958	41	0 22 2.99	103 31 11.2	*A. G. Harvard*	73
18	3 27 53.99	72 39 19.1	*A. G. Berlin A.*	943	42	11 3 23.57	88 19 13.7	rap à étoile *A. G. Albany*	4496
19	21 42 27.64	97 59 23.4	*A. G. Wien-Ottak.*	7638	43	0 19 43.75	77 14 23.2	*A. G. Leipzig I*	99
20	0 23 13.92	87 37 11.9	*A. G. Albany*	81	44	7 22 52.75	74 31 18.2	*A. G. Berlin A.*	2845
21	0 19 32.02	87 42 1.2	*A. G. Albany*	67	45	7 24 14.42	74 43 31.4	*A. G. Berlin A.*	2854
22	0 16 24.60	88 4 44.9	rap. à étoile 23		46	1 55 1.19	91 23 46.2	*A. G. Nicolajew*	393
23	0 14 11.16	88 8 8.2	*A. G. Albany*	18	47	1 57 16.53	91 16 19.4	*A. G. Nicolajew*	401
24	8 30 51.94	79 12 3.9	*A. G. Leipzig I*	3455					

32 − *A. G. Berlin A* 692 : Δ *A. R.* = $+2^m$ $5^s.73$; Δ *D. P.* = −12′15″.6
42 − *A. G. Albany* 4496 : Δ *A. R.* = +1 27 .72 ; Δ *D. P.* = + 10 .3

REMARQUES

Planètes. (385) *Ilmatar*, Oct. 15, la fin de l'observation s'achève par un ciel nébuleux. (551) *Péraga*, Mai 14, le ciel se couvre.

Comète périodique *Tempel II*. Juil. 20, la Comète, estimée de 14e grandeur, a une condensation assez mal définie située au S. W. de la chevelure, laquelle semble s'allonger à l'opposé sur 1′ à 1′.5 d'étendue.

Observatoire de Besançon,
1921, décembre 15.

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENN., WITH A $4\frac{1}{2}$-INCH REFRACTOR,

By A. W. QUIMBY.

1921	Time	New Grs.	Total Grs.	Total Spots	Fac Grs.	Def.
July 1	11	3	5	17	1	fair
2	7		5	66	1	fair
3	7		5	34	1	fair
4	7	–	3	25	1	fair
5	7	–	3	35	1	fair
6	7		2	44	1	fair
7	7		2	46	1	fair
8	7	1	3	42	1	fair
9	7	1	4	26		fair
10	7	0	4	13	0	poor
12	6	1	4	13	3	fair
13	11	–	4	13	3	fair
14	7		2	13	2	fair
15	6	–	1	7		fair
16	6	–	1	7	1	fair
17	6	–	1	7	1	fair
18	6	–	1	2		fair
19	12	–	1	4	–	poor
20	6	1	2	5	1	fair
21	6	1	1	2	2	fair
22	6	–	1	4	1	fair
23	6	1	1	3	1	fair
24	6					fair
25	6	1	1	2	1	fair
26	6	1	2	16	1	fair
27	6		2	13	1	fair
28	6	–	2	20		fair
29	6	–	1	10		poor
30	6	–	1	27	1	fair
31	6		1	20		fair
Aug. 1	6	–	1	13		fair
4	6	–	1	6	1	fair
5	6		1	2	1	fair
6	6	–	–		–	fair
7	8					fair
8	6	–	–			fair
9	6		–		1	fair
10	6	–	–			fair
11	6	1	1	6		fair
12	6	–	1	1	–	poor
13	6	1	2	3	2	fair
14	6	–	1	1		poor
15	6	–	1	1		fair
16	6	1	2	2		fair
18	6	1	3	17	3	fair
19	7	–	2	18		fair
Aug. 20	7		2	10		fair
21	7	2	1	8	2	fair
22	7		1	8	2	fair
*23	7		2	4	1	fair
24	7		2	8		fair
*25	7		2	12	1	fair
*26	7		1	10		fair
*27	7		2	14	1	fair
*28	7		2	14	1	fair
*29	7		2	10		fair
*30	7		1	5		fair
*31	7	1	2	3	1	fair
Sept. 1	10	1	2	2	1	fair
2	8		1	1	1	fair
3	7	2	2	5	1	fair
4	7					fair
5	7	–	–			fair
6	10					poor
7	7					fair
8	7		–		–	fair
9	7	–	–			fair
10	7	–	–			fair
11	7	1	1	9	–	fair
12	12	1	2	8	1	fair
13	7		2	8	1	fair
14	7		2	6	2	fair
15	7	1	2	6	1	fair
16	7	–	2	6		fair
17	5	–	2	4		fair
18	7	1	3	11		fair
19	7	–	3	6	1	fair
20	7		2	8		fair
22	7	–	2	2	–	fair
23	7	–	2	3	1	fair
24	7	1	3	7	2	fair
25	7	–	1	8		fair
26	7		1	8		fair
27	7	1	1	5		poor
28	7	1	1	11	–	fair
29	7	1	1	13	2	fair
30	7	–	–	–	1	fair
Oct. 1	7				–	fair
2	7					fair
3	7	–	–			poor
Oct. 4	7	–	–	–		fair
5	7		–	–		fair
6	5	–	–		1	fair
7	7		–	–		fair
8	7	1	1	1	2	poor
9	7					poor
10	5	1	1	1	1	fair
11	7	–	1	1	1	fair
12	7	1	2	6	–	fair
13	7	–	2	1	–	fair
14	7	1	2	1		fair
15	7	–	1	1	1	fair
16	7	–	1	1	1	fair
17	7	–	1	1		fair
18	7		1	1	–	fair
19	7	–	1	1		fair
20	7	–	1	1		fair
21	7	–	1	1	1	fair
22	7	–	1	1	–	fair
23	7	2	3	35	1	fair
24	1	–	3	64	2	good
25	7	–	2	47	1	fair
26	7	–	2	38	1	fair
27	7	–	2	28	1	fair
28	7	–	2	14	1	fair
29	7	–	2	8	1	fair
30	4	–	1	2		fair
31	2	–	1	1		poor
Nov. 1	4	–	1	1	1	fair
3	3	–	–	–	–	fair
4	7	–	–	–		fair
5	7			–		fair
6	7		–		–	fair
7	7		–		–	fair
8	7	–	–		–	fair
10	7	–	–			fair
11	7	–	–	–	–	fair
13	7	1	1	1	1	fair
15	7	–	1	1		fair
16	7	–	1	1		fair
17	10	–	1	1		poor
18	7	2	3	6	2	fair
19	10	1	4	10	1	fair
20	1	–	4	10	1	poor
22	9	–	3	16	1	fair
23	9	–	3	25	1	fair

*With 2″ refractor.

1921	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.	1921	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.	1921	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
Nov. 25	8	–	3	21	1	good	Dec. 9	10					poor	Dec. 20	8		3	23	1	fair
26	8		2	6		fair	10	9	1	1	1	1	poor	21	10		2	8		poor
29	12		1	1		poor	11	12	1	2	11	1	poor	22	8	1	2	12		fair
30	12		1	1	1	poor	12	1		2	18	1	poor	23	10	–	1	4		poor
Dec. 1	8					fair	13	1		2	25		poor	25	1		1	2	–	poor
2	12					fair	14	1		1	10		poor	26	8		1	2	1	fair
3	8					fair	15	12		1	10		poor	27	8	1	2	5	1	fair
4	8					poor	16	9	1	2	11	1	poor	28	8		1	2	–	fair
5	8					poor	17	8		2	11		poor	29	4					fair
6	8					poor	18	8	1	3	48	2	poor	30	8			–	–	fair
7	8					poor	19	8	–	3	12	1	poor	31	1		–	–	–	fair
8	2					poor														

THE PARALLAXES OF THREE WOLF-RAYET STARS,

By LAURA E. HILL.

At the request of Dr. Van Maanen, three Wolf-Rayet stars were placed on the parallax program of the Dearborn Observatory, with the results as here given. The parallaxes of *B. D.* 35° (4001) and *B. D.* 35° (4013) were determined from nineteen plates, extending from September 1916 to October 1920, using nine comparison stars. The parallax of *B. D.* 36° (3956) was obtained from sixteen plates extending from September 1916 to April 1921, using eight comparison stars.

Star	α	δ	Mag.	Rel. Parallax	Rel. μ_x
B. D. 35° (4001)	20h 6′	35° 53′	8.5	+0″.006 ±0″.010	−0″.002 ±0″.005
B. D. 35° (4013)	20 8	35 54	8.0	+0 .052 ±0 .012	+0 .008 ±0 .006
B. D. 36° (3956)	20 14	36 21	7.8	+0 .025 ±0 .010	+0 .005 ±0 .005

Other determinations of the parallaxes for these stars have been published as follows:

Van Maanen	*B. D.* 35° (4001)	+0″.011 ±0″.005	Contributions of Mt. Wilson Observatory, No. 136
	B. D. 35° (4013)	+0 .002 ±0 .003	
	B. D. 36° (3956)	0 .005 ±0 .006	No. 158
Kapteyn	*B. D.* 35° (4001)	+0″.00	*Astronomische Nachrichten* 3475
	B. D. 35° (4013)	+0″.03	
	B. D. 36° (3956)	+0 .09	

Dearborn Observatory,
11. January, 192

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OBSERVATIONS OF THE SATELLITES OF *SATURN*, 1910-11,

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

BY ASAPH HALL.

[Communicated by Captain W. D. MacDougall, U. S. Navy, Superintendent, U. S. Naval Observatory.]

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
			Mimas-Tethys					
	h m s	°	h m s	″				
1910 Sept. 12	13 23 23	198.89	13 24 58	12.42	4 , 4	2	388, Red.	
26	14 8 34	91.26	14 9 35	67.28	4 , 4	2-3	388, Brt	*Mimas* very faint.
Oct. 17	11 35 39	77.74	11 40 5	63.80	4 , 5	2	388, Brt	Moonlight. Too close to planet to finish.
18	11 9 23	198.35	11 18 55	6.43	2 , 4	2	388, Brt	
			Mimas-Rhea					
1910 Oct. 17	10 50 35	185.71	10 47 30	22.22	4 , 4	2	388, Brt	*Mimas* very faint. Moonlight.
			Enceladus-Tethys					
1910 Sept. 12	14 12 27	253.19	14 11 11	63.18	1 , 1	2	388, Red	
12	14 47 9	250.18	14 49 53	57.41	1 , 1	2	388, Brt	
16	13 11 20	254.66	13 11 52	13.27	1 , 4	2	388, Brt	Moonlight.
22	12 22 47	105.97	12 26 1	64.76	1 , 1	2-3	388, Brt	Moonlight. Clouds.
29	13 38 43	111.96	13 37 28	11.38	1 , 1	2-3	388, Brt.	
Oct. 1	12 8 40	261.26	12 11 30	58.10	4 , 1	3	388, Brt	
5	11 54 23	249.29	11 54 26	8.56	4 , 1	2-3	388, Brt	
10	11 18 23	305.24	11 19 17	5.46	4 , 4	3-4	388, Brt	
Nov. 19	10 30 25	271.15	10 31 9	13.37	4 , 4	2	388, Brt	
25	10 6 8	250.50	10 4 10	36.79	1 , 1	3	388, Brt	
Dec. 9	8 58 42	83.94	9 13 22	10.67	2 , 2	2-3	388, Brt	*Enceladus* too faint to finish.
17	8 5 50	277.70	8 6 0	72.27	1 , 1	2	388, Brt	
1911 Jan. 6	7 0 47	90.62	7 3 44	77.59	1 , 4	3-4	388, Brt	
			Tethys-Dione					
1910 Sept. 7	13 10 21	331.46	13 10 28	18.62	4 , 4	4	388, Brt	
9	14 54 3	162.14	14 50 29	18.28	4 , 1	3-4	388, Brt	
15	13 14 55	98.81	13 16 11	44.61	4 , 4	3-4	388, Brt	
17	12 11 11	160.20	12 12 3	34.73	4 , 4	2-3	388, Brt	Moonlight. Haze.
29	14 11 0	53.57	14 47 11	50.91	1 , 1	2-3	388, Brt	Haze.

Tethys-Dione (Continued)

Date	W. M. T.		W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
	h m s		h m s					
1910 Oct. 1	12 18 11	87.92	12 51 30	73.22	1 , 1	3	388, Brt	
5	11 21 34	301.11	11 25 3	52.01	1 , 1	3	388, Brt	
11	12 37 11	267.47	12 38 35	106.86	1 , 4	4	388, Brt	
12	12 3 3	95.12	12 1 57	101.57	1 , 5	3	388, Brt	Faint. Haze. Clouded.
Nov. 18	8 12 25	275.30	8 43 2	98.41	1 , 1	3	388, Brt	
Dec. 25	8 12 35	91.01	8 14 43	81.60	1 , 1	3	388, Brt	
1911 Jan. 4	8 15 7	270.55	8 17 27	93.53	4 , 1	3	388, Brt	
6	8 48 16	281.10	8 51 29	67.00	1 , 4	3-4	388, Brt	

Tethys-Rhea

Date	W. M. T.		W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
1910 Sept. 7	13 31 55	169.83	13 32 36	19.92	4 , 1	4	388, Brt	
9	15 37 28	282.47	15 36 30	75.37	1 , 4	3-4	388, Brt	
15	13 51 35	241.20	13 55 3	71.58	4 , 4	3-4	388, Brt	
17	12 52 38	93.37	12 52 40	81.06	4 , 1	3	388, Brt	
29	11 11 41	127.36	11 11 23	22.61	4 . 4	2-3	388, Brt	
Oct. 1	13 31 16	59.12	13 35 35	68.97	1 , 4	3	388, Brt	
Nov. 18	9 10 25	233.15		. . . .	2 , 0	3	388, Brt	Clouded.
25	10 13 27	304.73	10 45 56	60.34	4 , 4	3	388, Brt	
26	8 51 41	258.41	8 54 54	80.72	1 , 4	3	388, Brt	
Dec. 25	9 3 41	89.08	9 7 59	140.34	4 , 4	3	388, Brt	

Dione-Rhea

Date	W. M. T.		W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
1910 Sept. 7	12 46 33	166.95	12 47 23	36.33	4 , 4	4	388, Brt	
15	14 25 59	255.67	14 25 59	113.92	4 , 4	4	388, Brt	
16	15 25 39	101.95	15 24 32	118.33	4 , 4	3	388, Brt	
28	12 28 27	280.08	12 28 31	110.50	4 , 1	3-4	388, Brt	
Oct. 1	11 12 34	14.11	11 13 15	33.25	1 , 4	3	388, Brt	
5	10 18 28	95.70	10 19 7	120.18	1 , 4	3	388, Brt	
10	11 17 15	84.16	11 18 16	28.88	1 , 4	3-4	388, Brt	
11	11 42 43	3.26	11 44 5	21.52	1 , 4	4	388, Brt	
Nov. 18	8 21 14	121.81	8 21 50	62.01	1 , 4	3	388, Brt	
19	11 6 53	77.01	11 10 1	71.01	1 , 4	3-4	388, Brt	
26	9 21 52	250.18	9 22 23	57.69	1 , 1	3	388, Brt	
Dec. 13	10 2 37	16.77	10 1 15	37.90	1 , 4	3-4	388, Brt	

Rhea-Titan

Date	W. M. T.		W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
1910 Sept. 7	13 59 29	37.912	14 0 7	89.71	4 , 1	1	388, Brt	
7	11 36 10	36.027	11 36 6	86.81	1 , 4	4	388, Brt	
9	13 28 21	330.810	13 29 13	37.13	1 , 1	3-4	388, Brt	
9	11 6 2	332.289	11 5 41	37.00	1 , 4	3-4	388, Brt	
15	12 36 21	211.471	12 36 5	13.56	4 , 1	3-4	388, Brt	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
				Rhea-Titan (Continued)				
	h m s	°	h m s	″				
1910 Sept. 16	14 0 8	237.087	14 2 17	71.29	4, 4	3	388, Brt	
16	14 39 57	236.856	14 41 47	72.02	4, 4	3	388, Brt	
20	13 4 28	85.387	13 5 51	217.06	4, 4	3	388, Brt	Moonlight.
20	13 49 2	85.044	13 52 2	213.48	4, 4	3	388, Brt	
22	13 11 1	83.737	13 11 38	123.53	4, 4	3	388, Brt	Clouds.
26	15 2 1	279.688	15 2 25	205.22	4, 4	2–3	388, Brt	
28	12 1 29	272.220	12 2 6	108.24	4, 4	3–4	388, Brt	
Oct. 1	10 16 57	244.157	10 18 57	163.59	4, 4	3–4	388, Brt	
5	10 20 24	108.993	10 22 45	101.85	4, 4	3	388, Brt	
10	10 33 1	327.049	10 34 49	47.28	4, 4	3–4	388, Brt	
11	10 55 20	9.945	10 56 8	37.47	4, 4	4	388, Brt	
12	11 20 19	321.130	11 27 38	75.34	4, 4	3	388, Brt	
16	10 24 18	234.331	10 26 9	77.01	4, 4	3–4	388, Brt	Windy.
17	12 45 54	240.373	12 47 58	60.40	4, 4	2	388, Brt	
18	10 38 54	240.744	10 41 32	90.55	4, 4	2	388, Blk	Moonlight.
20	11 58 45	107.593	12 1 54	211.74	4, 4	3–4	388, Brt	Moonlight.
20	12 46 1	106.928	12 45 39	215.38	4, 4	3–4	388, Brt	
Nov. 17	8 30 5	238.323	8 31 16	63.92	4, 4	4	388, Brt	Clouded.
26	9 55 55	72.568	9 57 18	178.53	4, 4	3	388, Brt	
Dec. 9	9 52 17	92.750	9 52 3	277.89	4, 4	2–3	388, Brt	
13	9 5 30	45.679	9 6 44	43.25	4, 4	3	388, Brt	
21	8 6 39	226.111	8 8 13	85.39	4, 4	3	388, Brt	
27	8 33 2	84.377	8 35 45	204.52	4, 4	2	388, Brt	
29	7 50 43	333.456	7 50 28	78.98	4, 4	3–4	388, Brt	Clouded.
30	7 24 58	286.063	7 26 44	153.42	4, 4	3	388, Brt	
1911 Jan. 10	8 24 46	90.555	8 24 58	272.97	4, 4	2–3	388, Brt	Haze. Clouds.
16	7 55 57	288.814	8 0 29	172.27	4, 4	2–3	388, Brt	
				Titan-Hyperion				
1910 Sept. 26	12 12 13	244.844	12 12 38	125.08	4, 4	2	388, Red	*Hyperion* very faint.
27	12 41 19	220.203	12 42 52	73.46	4, 4	2–3	388, Red	
28	11 7 43	174.910	11 9 1	53.38	4, 4	3–4	388, Red	*Hyperion* very faint.
Oct. 5	12 37 53	133.760	12 39 46	34.01	4, 4	3	388, Red	*Hyperion* very faint.
				Titan-Japetus				
1910 Sept. 22	13 58 32	325.346	13 58 56	165.26	4, 4	3	388, Brt	
22	14 50 51	325.069	14 54 3	164.14	4, 4	3	388, Brt	
24	11 28 24	330.861	11 27 58	108.54	4, 4	3	388, Brt	Clouds.
24	12 15 58	331.275	12 23 42	107.37	4, 4	3	388, Brt	Clouded.
26	13 9 8	8.144	13 10 47	83.19	4, 4	2	388, Brt	
27	13 31 34	12.842	13 31 1	89.90	4, 4	2–3	388, Brt	Clouds.
28	11 36 42	1.793	11 36 35	96.13	4, 4	3–4	388, Brt	
29	13 7 9	334.650	13 9 17	117.52	4, 4	2–3	388, Brt	*Japetus* very ft. Clouds. Haze.

Titan-Japetus (Continued)

Date		W. M. T.	s	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
		h m s		h m s					
1910 Dec.	9	10 44 55	323.092	10 58 8	207.77	2, 2	2-3	388, Brt	*Japetus* too faint to finish.
	13	8 26 [illegible]	306.563	8 27 23	123.30	1, 1	2-3	388, Brt	Haze.
	17	8 57 22	317.919	9 0 20	98.10	1, 1	2	388, Brt	
	21	8 51 36	279.134	8 53 36	114.62	1, 5	3	388, Brt	
1911 Jan.	4	8 46 28	252.571			2, 0	3	388, Brt	Driving clock stopped.
	16	8 38 24	176.271	8 41 9	192.51	1, 1	2-3	388, Brt	

Titan-Japetus

Date		W. M. T.	Δα	Δδ	Comp.	Seeing	Power and Illum.	Remarks
				″				
1910 Sept.	12	15 23 48	+42.940	+198.55	24, 8	2-3	388, Brt	*Japetus* very faint. Clouded.
Oct.	17	13 53 54	31.515	−116.23	30, 10	2	388, Brt	[Poor observation.
	18	12 0 33	35.341	−118.55	27, 9	2	388, Blk	Moonlight.
	20	11 9 57	−42.068	−144.61	30, 10	2	388, Brt	

Comp. = transits.
Seeing: 2 = good, 3 = fair, 1 = poor.
Power and Illum.: Blk = black wires, Brt = bright field, Red = red wires.
Clark micrometer used before 1910 Nov. 6. Value of one revolution
$= 9''.9329 + 0''.0000525\,(t - 50^\circ \mathrm{F.}) + 0''.0255\,(1^{\mathrm{in.}}.280 - \text{focal scale})$.
Warner and Swasey micrometer used after 1910 Nov. 6. Value of one revolution
$= 10''.5752$ (for $t = 32^\circ$ F. and focal scale $= 3^{\mathrm{in.}}.170$).

U. S. Naval Observatory, Washington, D. C., 1922 Feb. [illegible]

ON PROGRESSIVE CHANGES IN LATITUDE,*

By FRANK SCHLESINGER.

In a recent Bulletin of the Department of Geology of the University of California (No. 7, Volume 12), Professor Lawson calls attention to an apparent increase in the latitude of Ukiah, the California station of the International Latitude Service. This is progressive and [illegible] amounts to nearly 0″.01 per [illegible]. Professor Lawson was led to examine these changes in latitude for evidence for or against his theory of the cause of earthquakes. Such a creep at Ukiah and a similar one at the Lick Observatory, to which he calls attention, would be strong corroboration of this theory. In a paper† read at the recent meeting of the American Astronomical Society (Swarthmore, December 30, 1921), Mr. Walter D. Lambert of the U. S. Coast and Geodetic Survey, examined the data for all six of the international stations and found that, with the exception of the one in Japan, all showed this progressive increase. He suggests that the effect may be partly due to erroneous proper-motions, and partly to a progressive change in the position of the pole.

The observations at the international stations were reduced with the use of proper-motions computed for these stars by Dr. Fritz Cohn (Centralbureau der Internationalen Erdmessung, Neue Folge der Veröffentlichungen, No. 2, Berlin 1900) from an examina-

* This paper has also been printed in the Journal of the Washington Academy of Sciences, Volume 12, page 28, under the title "The Latitude of Ukiah and the Motion of the Pole."

tion of all star catalogs published up to that time. The systematic corrections and weights used are those of AUWERS. This note is concerned with an inquiry concerning the changes that would be introduced into the computed latitudes if Boss's system of declinations and proper-motions had been used instead of AUWERS'.

There are several ways in which we may proceed. The most direct is to form the differences in proper-motion for those stars in the observing program that are also to be found in Boss' *Preliminary General Catalog*. The utility of this procedure depends upon the number of stars common to both lists, and upon the accordance of the differences. From an examination of the material it appears that nearly half the latitude stars are in the *Preliminary General Catalog*, and that the differences run smoothly.

The international observing program, which is the same for all of the stations, includes 192 stars. Most of these culminate near the zenith. The original list (which was afterwards modified in this respect), contained 24 pairs of stars at large zenith distances, the object being to check the refraction from night to night. As systematic corrections to circumpolar stars are apt to be different from the average of the others, I omit from this discussion the 24 northern components of these refraction pairs. Of the remaining 168 stars, 78 are found in the *Preliminary General Catalog*. The table below gives the individual differences.

P. G. C. No.	COHN *minus* *P. G. C.*	*P. G. C.* No.	COHN *minus* *P. G. C.*	*P. G. C.* No.	COHN *minus* *P. G. C.*	*P. G. C.* No.	COHN *minus* *P. G. C.*	*P. G. C.* No.	COHN *minus* *P. G. C.*
	″		″		″		″		″
66	+.010	1146	−.010	2409	+.025	3518	+.012	4980	−.001
154	0	1234	+ 10	2430	− 4	3552	+ 14	5035	+ 12
231	+ 35	1275	+ 11	2447	+ 14	3931	+ 11	5141	+ 7
270	0	1315	+ 7	2626	+ 6	3969	+ 22	5170	+ 15
298	− 12	1393	− 7	2684	+ 14	4021	− 5	5267	+ 17
434	+ 8	1520	+ 7	2728	+ 14	4270	+ 5	5378	+ 13
480	+ 6	1564	+ 21	2741	+ 5	4307	+ 12	5549	+ 5
536	+ 13	1615	+ 5	2765	+ 22	4343	+ 17	5567	0
620	+ 14	1658	− 2	2852	+ 16	4431	+ 11	5669	+ 4
729	+ 13	1692	+ 12	2926	+ 16	4480	+ 12	5721	+ 2
761	+ 7	1901	+ 20	2940	+ 23	4491	+ 5	5834	− 9
845	+ 23	1952	+ 12	2964	+ 9	4601	+ 11	5858	+ 10
873	+ 6	1986	+ 14	3138	+ 21	4653	− 8	5887	− 7
950	+ 18	2079	+ 4	3233	+ 16	4781	+ 5	6031	− 2
970	+ 5	2101	− 5	3279	+ 4	4912	+ 10		
1027	+ 8	2220	− 1	3432	+ 11	4942	+ 7	..	....

The mean of these differences gives:

Cohn *minus* Preliminary General Catalog

$$= +''.0087 \pm ''.00068$$

This probable error was derived merely from the discordance of the separate differences. It must not be taken as an indication of the accuracy of the proper-motions since both authorities use much the same list of catalogs with much the same weights; it merely indicates how competent 78 cases are to determine the difference between the two systems of proper-motions.

A difference in systems of proper-motion implies a difference in the adopted constants of precession, since the latter cannot be determined without making an assumption as to the totality of proper-motions. We do not need to concern ourselves with this matter here, for the precession in declination is $n \cos \alpha$; hence any small variation of n will introduce a small periodic term in the differences given above, but will be eliminated from the mean of the motions of stars that are uniformly distributed in right ascension.

In the following table the first column gives the names of the six stations; the second, their longitudes west of Greenwich; the third, the progressive changes in latitude deduced by MR. LAMBERT, using the mean of the two sets of results with the data collected respectively on the twelve months basis and on the fourteen months basis; the fourth, the progressive changes that we should derive with the use of Boss's

proper-motions, computed by subtracting ″.0087 from the corresponding number in the third column.

Station	Longitude	Progressive Change with COHN's Proper-motions	Progressive Change with BOSS's Proper-motions
	°	″	″
Mizusawa	−141	+.0008	−.0079
Tschardjui	−63	+.0110	+.0023
Carloforte	−8	+.0053	−.0034
Gaithersburg	+77	+.0103	+.0016
Cincinnati	+84	+.0099	+.0012
Ukiah	+123	+.0106	+.0019

It will be seen that the use of BOSS's system reduces the apparent changes in the latitude, except in the case of Mizusawa. In fact, excluding Mizusawa, the results at the other stations are now such as may come within the realm of accidental errors; though the one for Carloforte, in view of the number and accuracy of the observations at this station is somewhat larger than we should expect as the result of chance.

Our conclusion is that the present data can be interpreted without assuming that the latitude of any station except Mizusawa is changing to any serious extent.

MR. LAMBERT, in the paper already cited, notes that the apparent changes for the three stations in eastern longitudes, are on the average less than those in western longtiudes, and suggests that the pole itself may be moving progressively, roughly in the direction of our Atlantic Coast. If we exclude the results at Mizusawa, the evidence for such a progression would be very meagre. We have the choice of assuming that the latitude of Mizusawa is changing by about 0″.008 (25 centimeters) per annum, or that the pole is moving by a little more than half this amount. The former hypothesis leads to somewhat smaller outstanding residuals. I prefer this hypothesis, but in the present state of our information it is not possible to distinguish between the two with anything like certainty.

Whichever of these alternatives we adopt, the progressive change in the latitude of Ukiah can be only a small fraction of that deduced by PROFESSOR LAWSON from his examination of the published latitudes, computed with DR. COHN's proper-motions. This does not necessarily imply that the evidence is now against the "elastic rebound" explanation of earthquakes. It does mean, however, that the evidence in its favor apparently afforded by the published results for Ukiah, is now shown (principally through MR. LAMBERT's work) to be weak or even altogether absent. It may be that such evidence is forthcoming at Mizusawa, which of all the latitude stations is in the region most likely to show seismic effects.

Incidentally, the present paper affords support for the preference of BOSS's system of declinations over AUWERS'. To accept the latter as applying to the latitude observations is equivalent to supposing that all six of the latitude stations (with the possible exception of Mizusawa) are moving north. BOSS's proper-motions, on the other hand, greatly reduce these apparent motions and make the sum of them practically zero.

Owing to the war and other causes, three of the international stations have now been discontinued. The remaining ones are at Mizusawa, Ukiah and Carloforte. It is well recognized by astronomers and geodesists that more stations should be established as soon as possible. From several different points of view it would be profitable to resume observing at the abandoned international stations and particularly at Gaithersburg. If it should not be found possible to re-occupy this station permanently, it would still be of great service if the observations could be maintained for a limited period.

Yale University Observatory,
February 1, 1922.

OBSERVATIONS OF MINOR PLANETS,

MADE AT ANN ARBOR WITH THE 12⅝-INCH REFRACTOR OF THE DETROIT OBSERVATORY,

BY D. B. McLAUGHLIN.

1921	G. M. T.	★	No. Comp.	Planet — ★ Δα	Planet — ★ Δδ	Planet's Apparent α	Planet's Apparent δ	Log pΔ for α	Log pΔ for δ
			(30) *Urania*						
	h m s			m s	′ ″	h m s	° ′ ″		
Jan. 3	15 31 18.6	1	10, 10	0 31.55	−3 1.1	2 25 58.05	+17 18 20.2	9.4339	0.6088
9	15 31 8.6	2	10, 10	0 5.67	−10 29.3	2 30 15.12	+17 28 41.6	9.4787	0.6467
11	16 24 12.1	3	8, 8	−0 30.12	−2 0.5	2 31 55.69	+17 33 18.6	9.5748	0.6555
12	17 1 52.1	3	8, 8	+0 21.05	+0 22.3	2 32 16.85	+17 35 41.3	9.5988	0.6816

1921 G. M. T.	★	No. Comp.	Planet — ★ Δα	Planet — ★ Δδ	Planet's Apparent α	Planet's Apparent δ	Log pΔ for α	Log pΔ for δ
			(1) *Ceres*					
h m s			m s	′ ″	h m s	° ′ ″		
Jan. 17 14 34 53.4	4	8, 8	+0 10.34	+ 3 37.6	5 50 10.70	+28 25 56.5	9.1215*n*	0.3407
18 14 35 7.4	4	8, 8	−0 33.12	+ 6 7.7	5 49 27.24	+28 28 26.5	9.0904*n*	0.3371
31 16 27 0.3	5	*t*10, 8	−0 14.97	+ 9 35.4	5 42 40.07	+28 55 10.3	9.3696	0.3776
Feb. 18 13 54 53.5	6	8, 8	+0 4.43	− 4 2.1	5 42 14.26	+29 19 57.4	8.8365	0.2945*
			(20) *Massalia*					
Jan. 26 17 58 20.2	7	8, 8	+0 19.04	+ 1 44.7	8 34 52.04	+17 21 13.3	8.4052	0.5659
27 15 37 22.0	7	, 4	.....	+ 5 12.8	.....	+17 25 11.4	.....	0.5971
27 15 45 36.8	7	6,	−0 5.84		8 33 57.17	.....	9.3429*n*	......
31 18 39 43.6	8	*t*10, 8	−0 53.66	+ 8 53.1	8 29 19.49	+17 40 47.4	9.1835	0.5747
Feb. 18 16 45 41.8	9	10, 10	+0 42.98	+ 3 26.2	8 15 5.55	+18 37 17.0	8.9974	0.5500*
			(9) *Metis*					
Jan. 31 19 33 28.3	10	*t*10, 8	+2 31.25	+ 3 13.2	9 5 49.15	+25 59 39.3	9.3016	0.4307
Feb. 18 15 52 46.5	11	10, 10	+0 11.54	− 7 24.6	8 48 5.29	+27 11 8.4	8.8992*n*	0.3615*
20 15 20 11.9	12	8, 8	+0 22.72	+ 7 48.3	8 46 29.30	+27 14 54.8	9.0965*n*	0.3709*
21 15 23 31.2	12	8, 8	−0 23.68	+ 9 28.3	8 45 42.90	+27 16 34.9	9.0344	0.3655*
			PLANET DISCOVERED FEBRUARY 3, 1921	**By Comas Sola, Barcelona, Spain**				
Feb. 11 18 40 14.8	13	12, 12	+0 40.67	+ 2 48.9	9 2 45.49	+17 35 11.9	9.2406	0.5793
15 20 31 34.6	15	12, 12	−0 55.82	+ 1 47.8	8 56 13.71	+16 43 34.1	9.5744	0.6613*
			(10) *Hygia*					
Feb. 18 18 29 45.0	17	10, 10	+0 0.63	−10 9.3	10 0 6.14	+ 8 3 40.1	8.9726	0.6935*
20 16 47 1.4	18	8, 8	−0 11.10	+ 5 28.9	9 58 32.70	+ 8 10 30.3	8.9250*n*	0.6919*
			(40) *Harmonia*					
Apr. 24 16 22 15.4	19	10, 10	−0 2.29	+ 4 33.2	14 15 13.76	− 6 45 52.4	9.1608*n*	0.8182
25 16 52 36.3	20	8, 8	−0 21.89	− 2 26.8	14 14 12.30	− 6 41 34.3	8.9029*n*	0.8492
			(4) *Vesta*					
Dec. 10 17 31 22.5	21	10, 10	−0 29.63	+10 36.4	2 43 48.88	+ 7 23 19.0	9.5412	0.7273

Observations marked with an asterisk were reduced by R. A. Rossiter, others by D. B. McLaughlin.

Mean Places for 1921 of Comparison Stars

★	α	Red. to App. Pl.	δ	Red. to App. Pl.	Authority
	h m s	s	° ′ ″	″	
1	2 26 31.18	+1.42	+17 21 22.2	+ 2.1	*A. G. Berlin A* 688
2	2 30 19.41	+1.38	+17 39 9.0	+ 1.9	*A. G. Berlin A* 704
3	2 32 24.44	+1.37	+17 35 17.4	+ 1.7	*A. G. Berlin A* 709
		+1.36		+ 1.6	

★	α	Red. to App. Pl.	δ	Red. to App. pl.	Authority
	h m s	s	° ′ ″	″	
4	5 19 58.05	+2.32	+28 22 25.6	− 6.7	*A. G. Cambridge (Engl.)* 2776
		+2.32		− 6.8	
5	5 12 52.89	+2.23	+28 15 10.7	− 5.8	*A. G. Cambridge (Engl.)* 2699
6	5 12 7.83	+2.00	+29 24 1.5	− 5.0	*A. G. Cambridge (Engl.)* 2688
7	8 31 0.91	+2.09	+17 20 13.5	−14.9	*A. G. Berlin A* 3442
		+2.10		−14.9	
8	8 30 10.87	+2.28	+17 32 8.9	−14.9	*A. G. Berlin A* 3403
9	8 14 29.27	+2.30	+18 31 5.2	−14.4	*A. G. Berlin A* 3272
10	9 3 15.59	+2.31	+25 56 14.7	−15.6	*A. G. Cambridge (Engl.)* 4833
11	8 47 51.33	+2.12	+27 18 17.2	−14.2	*A. G. Cambridge (Engl.)* 4721
12	8 46 1.17	+2.11	+27 7 20.5	−14.9	*A. G. Cambridge (Engl.)* 4707
		+2.11		−13.9	
13	9 1 54.75	+2.32	+17 25 19.4	−15.7	*A. G. Berlin A* 3673
14	9 2 32.50	+2.32	+17 32 38.7	−15.7	9.5 mag. connected with ★ 13; $\Delta\alpha = 37^s.75$, $\Delta\delta = +6'\,49''.3$
15	8 58 4.52	+2.32	+16 15 26.4	−15.7	*A. G. Berlin A* 3638
16	8 57 7.21	+2.32	+16 12 2.0	−15.7	9.5 mag. connected with ★ 15; $\Delta\alpha = -57^s.31$, $\Delta\delta = -3'\,24''.4$
17	10 0 3.21	+2.30	+ 8 14 6.0	−16.6	*A. G. Leipzig II* 5348
18	9 58 11.49	+2.31	+ 8 5 18.3	−16.9	*A. G. Leipzig II* 5339
19	11 45 13.27	+2.78	− 6 50 15.8	− 9.8	*A. G. Wien-Ottakring* 5068
20	11 44 31.44	+2.78	− 6 38 57.7	− 9.8	*A. G. Wien-Ottakring* 5063
21	2 44 14.13	+1.38	+ 7 42 30.3	−12.3	*A. G. Leipzig II* 1037

PARALLAX OF THE FAINT COMPANION STAR OF *CAPELLA*.

By RUTH M. TIBBLES.

Relative parallax = 0″.055 ± 0″.010

Proper-motion in R. A. = 0″.956 ± 0″.001

... the following values have been published:

PORTER AND SCHLESINGER

$\pi = 0''.067 \pm 0''.009$; ... $0''.077 \pm 0''.005$ *A. J.* 765

$= 0''.071 \pm 0''.008$ *A. J.* 773

LEE AND VAN BIESBROECK

$\pi = 0''.070 \pm 0''.005$ $\mu = 0''.063$ *A. J.* 779

Dearborn Observatory,
11 January 1922.

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... Barnard, Ernest W. Brown, F. R. Moulton, and R. S. Woodward.
... N. Y., ... to whom all Communications Should Be Addressed. Price $5.00 the Volume.
... March ... 1922.

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A TEST OF TWO METHODS OF MEASURING PARALLAX PLATES,

INCLUDING THE PARALLAXES OF SIX STARS,

By JENNIE V. FRANCE.

The following parallaxes were measured, at the suggestion of Dr. Schlesinger, for the purpose of testing two methods of measuring, both as to time and as to accuracy. The plates were taken at the Allegheny Observatory and measured at the Yale Observatory. The first method of measuring is with the reversing prism: the second, by reversing the plate in the engine. There were 95 plates in all, having four comparison stars of three images each. Each plate received the same number of readings, *i. e.*, three readings for each image in the direct and in the reversed positions. It was found that the average time for measuring one plate with the reversing prism was 17.8 minutes, and by reversing the plate, 23.0 minutes, or 30 per cent longer. The average time for computing up to the least-squares solution for one plate was 10.5 minutes by method (1) and 16.0 minutes by method (2), or 54 per cent longer. For the total time for measuring and computing an average set of 15 plates, including the least-squares solution, method (2) took 30 per cent longer.

There is a persistent difference in the size of the probable errors, those found by the second method being the smaller in each case. The average difference is 12 per cent. Consequently the following weights were given to the parallaxes: method (1), weight 0.8; method (2), weight 1.0. The adopted parallax in Table (1) is the weighted mean and the adopted probable error is the smaller of the two.

Whether the 12 per cent increase in accuracy warrants the use of the method of reversing the plate depends upon the circumstances at the observatory. In the case of the visual refractor, where so much time is spent at the telescope and the plates are slow in accumulating, it is perhaps best to reverse the plate. But where the plates accumulate with such rapidity as they do with the photographic refractor one is justified in using the reversing prism in spite of larger probable errors. However, if three more plates are taken method (1) will yield the same results as method (2) without the extra plates.

TABLE I

Summary of Parallaxes

No.	Name	α (1900)	δ (1900)	Durchmusterung Number	Visual Magnitude and Spectrum	Total Proper-Motion	Relative Parallax and Probable Error		Prob. Error for one Good Plate
		h m	° ′	°		″	″	″	″
527	*Lalande* 7116	3 46	+22 23	+22 583	7.8 G_0	.39	**+.031**	**±.009**	±.024
528	*Lalande* 8758	4 35	+38 5	+37 954	5.8 F_5	.25	**+.020**	**.010**	.032
529	*Lalande* 11870	6 9	+ 2 51	+ 2 1163	7.9 K_0	.26	**+.004**	**.006**	.020
530	58 *Cancri*	8 50	+28 18	+28 1666	5.2 G_5	.04	**−.008**	**.008**	.021
531	*μ Virginis*	14 38	− 5 13	− 5 3936	4.0 F_5	.34	**+.030**	**.005**	.015
532	*Lalande* 33251	18 1	+33 16	+33 3019	7.6 G_5	.20	**+.007**	**.007**	.019

The numbers assigned to these parallaxes are in continuation of other parallaxes derived from Allgeheny plates.

TABLE II

THE COMPARISON STARS

No.	Star 1 X	Star 1 Y	Star 1 Dep.	Star 2 X	Star 2 Y	Star 2 Dep.	Star 3 X	Star 3 Y	Star 3 Dep.	Star 4 X	Star 4 Y	Star 4 Dep.	Mean Magn. (Photogr.)	Constant Prism	Constant Reversing
	mm	mm		mm	mm		mm	mm		mm	mm			mm	mm
527	− 87	+ 8	.229	− 46	− 3	.347	+ 47	+ 57	.010	+ 86	− 3	.414	11.6	+ .1039	+ .0935
528	− 95	− 20	.178	− 32	+ 28	.344	+ 57	− 44	.178	+ 60	+ 5	.300	11.3	− 568	− 435
529	− 79	+ 44	.209	− 46	+ 21	.285	+ 39	− 21	.209	+ 44	− 12	.297	11.5	+ 1346	+ 1352
530	− 100	− 22	.243	− 1	+ 43	.300	+ 53	+ 30	.329	+ 54	− 66	.128	11.7	0	0
531	− 22	+ 78	.388	+ 4	− 44	.286	+ 45	− 62	.287	+ 87	− 6	.039	10.7	+ 816	+ 825
532	− 94	+ 18	.203	− 30	− 67	.226	+ 42	+ 46	.286	+ 49	+ 21	.285	10.5	+ 342	+ 330

These coordinates are referred to the parallax star as origin and are in the sense of increasing right ascensions and north polar distances.

(527) *Lalande* **7116**. $3^h 46^m$, $+22° 23'$

Plate Number and Observer	Date	Hour Angle	Parallax Factor	Time in Days	Wt.	Prism Solution	Prism Resid.	Reversing Solution	Reversing Resid.
		min.				mm	″	mm	″
7002J*	1916 Sept. 23	− 10	+ .83	− 483	0.6	− .0409	+ .022	+ .0263	+ .048
7040T	25	+ 13	+ .81	− 481	0.7	− 132	− 10	− 292	− 25
8554J	1917 Jan. 20	+ 3	− .84	− 364	1.0	− 118	− 42	− 264	+ 10
8627h	30	0	− .94	− 354	0.8	− 90	+ 26	− 254	+ 20
10397T	Sept. 13	+ 10	+ .94	− 128	0.9	+ 4	− 6	− 137	− 0
10455T	16	+ 3	+ .89	− 125	0.8	− 1	− 10	− 152	− 23
11842J	1918 Jan. 19	+ 16	− .83	0	0.5	0	− 31	− 132	− 3
15453J	1919 Jan. 19	+ 9	− .83	+ 365	0.8	+ 147	− 9	0	− 15
15486T	20	0	− .84	+ 366	1.0	+ 182	+ 41	+ 21	+ 46
15600h	27	+ 5	− .89	+ 373	0.7	+ 130	− 38	− 16	− 39
18062D*	Sept. 6	+ 6	+ .95	+ 595	0.8	+ 325	+ 86	+ 197	+ 82
18107J*	11	+ 5	+ .93	+ 600	0.6	+ 203	− 95	+ 84	− 86
18226J	20	+ 4	+ .86	+ 609	0.8	+ 263	− 10	+ 154	+ 13

	Prism	Reversing		Prism	Reversing
	mm	mm		mm	mm
$+10.00c + 7.53\mu + 0.50\pi =$	+ .0636	− .0799	$c =$	+ .0036	− .0410
$+169.59 \quad +2.81 =$	+ .6435	+ .5758	$\mu =$	+ .00364	+ .00384
$+7.62 =$	+ .0245	+ .0239	$\pi =$	+ .00165	+ .00245

	Prism	Reversing
Probable error for unit weight,	± ″.027	± .024
Annual proper-motion in R. A.,	+ ″.492 ± ″.008	+ ″.205 ± ″.007
Relative parallax,	+ ″.021 ± ″.010	+ ″.036 ± ″.009

Other determinations of this parallax are: Yerkes, + ″.035 ± ″.008; Mt. Wilson, Spectroscopic, + ″.030. PORTER gives + ″.193 for the proper-motion.

* Two exposures.

(528) *Lalande* **8758**, $4^h 35^m$, $+38° 5'$

Plate Number and Observer	Date	Hour Angle	Parallax Factor	Time in Days	Wt.	Prism Solution	Prism Resid.	Reversing Solution	Reversing Resid.
		m.				mm	″	mm	″
3552*H*	1915 Oct. 10	−15	+.80	−493	1.0	−.0322	−.006	−.0237	−.015
3585*J*	11	− 7	+.79	−492	1.0	− 349	− 47	− 251	− 36
4717*J*	1916 Feb. 21	+ 7	−.96	−359	0.9	− 257	+ 32	− 182	+ 10
6975*J*	Sept. 21	+ 6	+.94	−146	0.9	− 100	+ 80	− 14	+ 76
8713*J*	1917 Feb. 14	+ 9	−.94	0	0.9	− 155	− 66	− 73	− 69
8732*T*	15	+ 3	−.95	+ 1	1.0	− 70	+ 60	+ 5	+ 45
8759*J*	17	+ 5	−.96	+ 3	1.0	− 128	− 25	0	+ 35
10535*s*	Sept. 21	− 3	+.94	+219	0.9	+ 3	− 18	+ 105	+ 6
12037*T*	1918 Feb. 13	+13	−.94	+364	1.0	+ 65	+ 10	+ 138	− 3
12066*J*	14	− 5	−.94	+365	0.7	0	− 85	+ 86	− 80
12166*J*	26	+21	−.98	+377	1.0	+ 96	+ 48	+ 170	+ 35
14238*J*	1918 Sept. 27	+10	+.91	+590	0.8	+ 166	− 31	+ 220	− 72
14261*J*	29	+ 2	+.89	+592	1.0	+ 200	+ 18	+ 274	+ 7
18267*D*	1919 Sept. 25	+ 8	+.92	+953	0.7	+ 356	+ 1	+ 461	+ 38

	Prism	Reversing		Prism	Reversing
	mm	mm		mm	mm
$+12.80c + 14.90\mu - .65\pi =$	$-.0584$	$+.0509$	$c =$	$-.0099$	$-.0013$
$+229.60 + 2.04 =$	$+.9207$	$+1.0317$	$\mu =$	$+.00464$	$+.00456$
$+10.81 =$	$+.0300$	$+.0250$	$\pi =$	$+.00130$	$+.00138$

	Prism	Reversing
Probable error for unit weight,	±″.033	±″.032
Annual proper-motion in R. A.,	+″.247 ±″.008	+″.243 ±″.008
Relative parallax,	+″.019 ±″.010	+″.020 ±″.010

No other determination of this parallax has been published. Porter gives +″.225 for the proper-motion.

(529) *Lalande* **11870**, $6^h 9^m$, $+2° 51'$

Plate Number and Observer	Date	Hour Angle	Parallax Factor	Time in Days	Wt.	Prism Solution	Prism Resid.	Reversing Solution	Reversing Resid.
		m.				mm	″	mm	″
3872*T*	1915 Oct. 30	+10	+.81	−854	0.8	−.0158	−.006	−.0148	+.004
7589*H*	1916 Oct. 30	−14	+.81	−488	0.5	− 119	− 26	− 105	− 4
8831*J*	1917 Feb. 28	0	−.92	−367	1.0	− 134	− 64	− 119	− 45
8863*h*	Mar. 6	+ 3	−.95	−361	0.8	− 92	− 6	− 103	− 23
10900*J*	Oct. 26	− 2	+.85	−127	0.7	− 5	+ 66	− 59	− 9
12135*T*	1918 Feb. 22	0	−.86	− 8	0.8	− 7	+ 45	− 11	+ 44
12172*J*	26	+ 6	−.88	− 4	0.7	− 48	− 15	− 18	+ 34
12207*K*	Mar. 2	+15	−.93	0	0.8	− 1	+ 53	− 21	+ 26
14519*T*	Oct. 26	+ 6	+.85	+238	0.9	+ 20	+ 23	+ 24	+ 39
14650*J*	Nov. 6	− 7	+.74	+249	0.7	0	− 7	− 6	− 4
16060*h*	1919 Mar. 4	+ 8	−.94	+367	0.8	+ 8	− 12	+ 8	− 1
16074*J*	6	− 6	−.95	+369	0.8	+ 2	− 20	0	− 15
18540*D*	Oct. 17	+ 2	+.92	+594	0.6	+ 54	− 1	+ 28	− 25

(529) *Lalande* **11870**, $6^h\,9^m$ $+2°\,51'$ (*Continued*)

Plate Number and Observer	Date	Hour Angle	Parallax Factor	Time in Days	Wt.	Prism Solution	Prism Resid.	Reversing Solution	Reversing Resid.
		mm				mm	″	mm	″
19536*J*	1920 Feb. 19	+ 8	−.83	+719	0.5	+.0104	+.053	+.0078	+.029
19581*J*	29	+ 3	−.92	+729	0.5	+ 69	+ 1	+ 33	− 25
21986*J*	Oct. 10	0	+.96	+953	0.8	+ 146	+ 57	+ 127	+ 54
22022*J*	12	− 3	+.95	+955	1.0	+ 82	− 36	+ 83	− 15
22245*J*	22	− 2	+.88	+965	0.8	+ 64	− 64	+ 59	− 53

		Prism	Reversing		Prism	Reversing
		mm	mm		mm	mm
$+13.50c + 28.65\mu - .22\pi$	=	−.0045	−.0121	c =	−.0034	−.0038
$+138.26\mu + 15.61\pi$	=	+.5408	+.4845	μ =	+.00144	+.00134
$+10.75\pi$	=	+.0272	+.0245	π =	+.00037	+.00025

	Prism	Reversing
Probable error for unit weight,	±″.025	±″.020
Annual proper-motion in R. A.,	+″.077 ±″.005	+″.072 ±″.004
Relative parallax,	+″.005 ±″.008	+″.004 ±″.006

No other determination of this parallax has been published. PORTER gives +″.042 for the proper-motion

(530) **58** *Cancri*, $8^h\,50^m$, $+28°\,18'$

Plate Number and Observer	Date	Hour Angle	Parallax Factor	Time in Days	Wt.	Prism Solution	Prism Resid.	Reversing Solution	Reversing Resid.
		min.				mm	″	mm	″
1780*H*	1915 Apr. 13	+ 1	−.92	−941	0.9	+.0011	+.054	+.0052	+.044
1808*J*	14	− 3	−.93	−940	0.9	− 61	− 55	− 25	− 69
1832*D*	15	+25	−.93	−939	0.9	− 13	+ 45	+ 45	+ 34
5072*D*	1916 Apr. 10	+ 7	−.94	−578	0.9	− 27	+ 12	+ 15	− 7
8469*J*	Dec. 5	− 3	+.79	−339	0.5	0	+ 47	+ 24	+ 18
9054*W*[1]	1917 Apr. 3	+ 2	−.86	−220	0.7	− 42	− 35	0	− 26
11221*J*	Nov. 9	+ 1	+.95	0	0.7	− 33	− 4	+ 12	+ 3
12593*K*	1918 Mar. 29	+ 9	−.82	+140	0.9	− 7	+ 13	+ 14	− 4
14780*h*	Nov. 14	+10	+.93	+370	0.9	− 37	− 15	+ 26	+ 26
16394*J*	1919 Mar. 29	+13	−.82	+505	0.8	− 32	− 28	+ 24	+ 16
16451*T*	Apr. 5	0	−.87	+512	1.0	+ 7	+ 26	+ 4	− 13
16520*J*	13	+12	−.92	+520	0.9	− 22	− 45	+ 11	− 4
18789*J*	Nov. 8	+ 6	+.95	+729	0.4	− 62	− 53	− 30	− 54
18900*D*	11	+ 9	+.93	+735	0.7	− 50	− 38	− 29	− 54
19113*J*	Dec. 15	−16	+.70	+766	0.4	+ 59	+ 118	+ 47	+ 60
19781*D*	1920 Mar. 24	+16	.74	+863	0.8	− 11	+ 0	+ 12	+ 3
19804*J*	22	0	−.75	+864	0.6	+ 6	+ 25	+ 26	+ 23

[1] Two exposures

		Prism (mm)	Reversing (mm)		Prism (mm)	Reversing (mm)
$+12.90c + 7.81\mu + 4.86\pi$	=	$-.0249$	$+.0181$	$c =$	$-.0023$	$+.0013$
$+549.63 + 18.93$	=	$+.0084$	$-.0326$	$\mu =$	$+.00007$	$-.00007$
$+ 9.93$	=	$+.0046$	$-.0110$	$\pi =$	$-.00079$	$-.00035$

	Prism		Reversing	
Probable error for unit weight,	±″.024		±″.021	
Annual proper-motion in R. A.,	+″.004	±″.004	−″.004	±″.003
Relative parallax,	−″.012	±″.009	−″.005	±″.008

No other determination of this parallax has been published. Boss gives −″.011 for the proper-motion.

(531) μ *Virginis*, $14^h 38^m$, $-5° 13'$

Plate Number and Observer	Date	Hour Angle	Parallax Factor	Time in Days	Wt.	Prism Solution	Prism Resid.	Reversing Solution	Reversing Resid.
		mm.				mm	″	mm	″
9721*h*	1917 July 1	+26	−.81	−578	0.7	−.0186	−.003	−.0194	−.019
12084*J*	1918 Feb. 14	0	+.91	−350	0.7	− 74	+ 25	− 79	+ 13
12190*J**	Mar. 1	+ 4	+.82	−335	0.6	− 117	− 39	− 115	− 39
12239*J*	3	− 2	+.81	−333	0.7	− 94	− 7	− 77	+ 15
13304*J*	June 18	+12	−.68	−226	0.7	− 83	+ 15	− 105	− 18
13329*K**	19	+11	−.69	−225	0.6	− 62	+ 47	− 50	+ 60
13351*T*	23	+ 9	−.74	−221	1.0	− 86	+ 12	− 89	+ 4
13386*J*	27	+17	−.78	−217	0.8	− 103	− 15	− 87	+ 9
15666*T*	1919 Jan. 30	+ 8	+.93	0	0.8	0	+ 6	0	+ 6
15714*J*	Feb. 1	+ 7	+.94	+ 2	0.7	− 49	− 64	− 11	− 9
15781*T*	5	+12	+.94	+ 6	0.7	− 14	− 16	− 21	− 26
17222*h*	June 28	+16	−.76	+149	0.9	− 3	− 1	0	+ 6
19423*D*	1920 Jan. 29	+ 9	+.93	+364	0.7	+ 138	+ 76	+ 89	+ 9
19724*J*	Mar. 14	− 5	+.71	+409	0.8	+ 99	+ 9	+ 106	+ 22
20774*D*	June 28	+19	−.79	+515	0.8	+ 76	− 19	+ 93	+ 12
20795*J*	30	+18	−.82	+517	0.8	+ 73	− 23	+ 56	− 42

		Prism (mm)	Reversing (mm)		Prism (mm)	Reversing (mm)
$+12.00c - 2.25\mu + .19\pi$	=	$-.0333$	$-.0331$	$c =$	$-.0023$	$-.0024$
$+129.02 - .41$	=	$+.3253$	$+.3160$	$\mu =$	$+.00249$	$+.00242$
$+8.03$	=	$+.0152$	$+.0152$	$\pi =$	$+.00207$	$+.00207$

	Prism		Reversing	
Probable error for unit weight,	±″.020		±″.015	
Annual proper-motion in R. A.,	+″.133	±″.006	+″.129	±″.005
Relative parallax,	+″.030	±″.007	+″.030	±″.005

Other determinations of this parallax are: McCormick, +″.043 ±″.010; Mt. Wilson, spectroscopic, +″.048. Boss gives +″.106 for the proper-motion.

* Two exposures.

(532) *Lalande* **33251**, $18^h\ 1^m$, $+33°\ 16'$

Plate Number and Observer	Date	Hour Angle	Parallax Factor	Time in Days	Wt.	Prism Solution	Prism Resid.	Reversing Solution	Reversing Resid.
		min.				mm	"	mm	"
10037*J*	1917 Aug. 4	+13	−.67	−639	0.7	−.0001	.000	−.0001	−.018
10087*T*	12	+ 3	−.77	−631	0.8	− 0	− 1	+ 28	+ 26
10092*J*	16	− 8	−.81	−627	1.0	0	− 1	+ 6	− 6
12865*J*	1918 May 5	+ 7	+.72	−365	0.9	− 37	− 50	− 18	− 50
12936*J*	11	− 1	+.60	−356	1.0	− 6	− 4	+ 7	− 12
12962*J*	15	− 2	+.59	−355	0.9	− 5	− 3	+ 5	− 16
13859*J*	Aug. 6	+ 6	−.69	−272	0.9	+ 30	+ 50	+ 27	+ 36
13966*h*	17	+13	−.79	−261	1.0	− 17	− 19	+ 3	+ 1
16702*T*	1919 May 5	+ 4	+.72	0	0.6	− 1	+ 10	+ 26	+ 25
17667*J*	Aug. 1	+17	−.62	+ 88	0.8	+ 1	+ 15	0	+ 7
17717*D*	10	+11	−.74	+ 97	0.9	+ 29	+ 55	+ 24	+ 44
20031*D*	1920 Apr. 18	+ 8	+.88	+349	0.6	− 25	− 18	+ 21	+ 28
20085*J*	25	+ 8	+.82	+356	0.7	+ 2	+ 22	+ 29	+ 41
21076*D*	May 4	− 9	+.73	+365	1.0	+ 11	+ 35	+ 1	+ 1
21216*B*	Aug. 5	− 4	−.69	+458	1.0	− 22	− 10	− 21	− 12
21232*B*	13	+ 7	−.78	+466	1.0	− 31	− 23	− 46	− 47
21255*J*	20	−11	−.84	+473	1.0	− 44	− 42	− 26	− 18

	Prism	Reversing		Prism	Reversing
	mm	mm		mm	mm
$+14.80c - 7.12\mu - 2.75\pi =$	−.0108	+.0028	$c =$	−.0008	+.0002
$+245.52 \quad +4.03 =$	−0.303	−.0517	$\mu =$	−.00015	−.00022
$+8.03 =$	+.0016	+.0050	$\pi =$	.00000	+.00081

	Prism	Reversing
Probable error for unit weight,	±″.020	±″.019
Annual proper-motion in R.A.,	−″.008 ±″.005	−″.012 ±″.004
Relative parallax,	″.000 ±″.007	+″.012 ±″.007

No other determination of this parallax has been published. Porter gives ″.000 for the proper-motion.

Yale University Observatory, March 1, 1922.

THE *MOON'S* MEAN MOTION AND THE NEW TABLES,

By ERNEST W. BROWN.

The memoirs of Dr. J. K. Fotheringham* on the ancient eclipses and those of C. I. Taylor† and H. Jeffries‡ on tidal friction in shallow seas have largely cleared away the doubts that surrounded the old hypothesis that the *Moon's* apparent residual acceleration is, in reality, due to a retardation of the *Earth's* rate of rotation. While the importance of their work in clearing up a difficulty in the recorded observations of the *Moon* is not to be minimised, my immediate object in this note is to give briefly the numerical consequences as far as predictions of the *Moon's* place by means of the new tables are concerned, and to indicate how predictions for the unexplained minor fluctuations can best be made when, for example, it is desired to predict the time and terrestrial path of a solar eclipse with the best possible accuracy. I give also, at the end, a few errata which have crept into the tables.

Denoting the value of the mean longitude plus the great empirical term used in the new tables by T_0§

* *Monthly Notices*, Vol. 81, pp. 104-126.
† *Trans. Roy. Soc.*, Vol. 220, pp. 1-33.
‡ *Trans. Roy. Soc.*, Vol. 221, pp. 239-264.
§ *Monthly Notices*, Vol. 75, p. 510.

and that given by Dr. Fotheringham|| by $T_o + \delta T$, we have

$$T_o = 335^\circ\ 43'\ 27''.81 + 1336^r\ 307^\circ\ 53'\ 11''.80\ T + 7''.12\ T^2 + 0''.0068\ T^3 + 10''.71 \sin(100^\circ.7 + 140^\circ\ T).$$

$$T_o + \delta T = 335^\circ\ 43'\ 25''.26 + 1336^r\ 307^\circ\ 53'\ 13''.82\ T + 11''.91\ T^2 + 0''.0068\ T^3 + 13''.60 \sin(104^\circ.2 + 139^\circ\ T).$$

where T is the number of Julian centuries from 1800.0. Hence with sufficient accuracy for some centuries from the epoch

$$\delta T = -2''.55 + 2''.02\ T + 4.79\ T^2 - 2''.90 \cos(139^\circ\ T - 166^\circ) + (3.5 - T)\ 0''.187 \sin(139^\circ\ T - 166^\circ)$$

Dr. Fotheringham has shown that the representation of the modern observations up to 1890 is little altered by the application of this formula, but that those of later date are very considerably improved, expecially during the last decade. As far as the new tables are concerned, since the date of the analysis which determined the choice of the constants of the mean longitude, the difference between theory and observation has increased some 2″. At that date the best value available was a slight modification of that obtained by Newcomb in his last paper on the subject¶. It is true that his formula, which included a secular acceleration of $9''.07\ T^2$, I modified by changing the secular acceleration to $7''.12\ T^2$, but the modification gave substantially the same mean longitude from 1650 to 1930 as Newcomb's expression because the other constants and the great empirical term were changed in such a way as to achieve this numerical result. Thus the change δT in modern times is mainly due to an alteration of the secular acceleration from $9''.07\ T^2$ to $11''.91\ T^2$, the other changes made being those of constants which are always determined from observation.

The values of δT tabulated at intervals of 25 years are: —

Date	δT	Date	δT
	″		″
1750.0	−0.02	1875.0	−0.21
1775.0	+ .24	1900.0	+1.48
1800.0	+ .09	1925.0	+4.65
1825.0	− .18	1950.0	+9.42
1850.0	− .57		

|| *L. c.*, p. 125.

¶ Astronomical Papers of the American Ephemeris, Vol. IX, Part 1.

In order to obtain the minor fluctuations of the *Moon* from its place as predicted by the new theory (which includes the great empirical term), the values above given, properly interpolated, must be added to the numbers in the columns headed "Mer." in Tables I, II, of my paper "The Longitude of the *Moon* from 1750 to 1910."** For the purposes of prediction it will be sufficient to give here the results for the last twenty years.

In the table below are given, for the middle of the respective years, in the Column B-H the additions to the mean longitude used in Hansen's Tables with Newcomb's old correction and adopted in the *American Ephemeris* and *British Nautical Almanac* to the end of 1922 in order to reduce the results to the theory adopted in the new tables; the column δT is the correction noted above; the column O is the observed deviation of the *Moon* from the place predicted by the *Almanac*,†† and the column Th-O gives the resulting outstanding errors or minor fluctuations to date.

For predictions after 1922 estimates of the future fluctuations should be made from the numbers in the last column to be formed after those in the column O have been inserted and added to δT. It will be noticed that after a rapid increase (which has followed a decrease) the numbers in the column Th-O have been nearly stationary or slightly decreasing for a few years. As ephemeris predictions for eclipses have to be made some three years in advance, estimates decreasing about 0″.5 a year for some years in this column are indicated; these would give corrections to the new tables of 7″ for 1923, of 6″.5 for 1924 and of 6″.0 for 1925.6. It is, of course, inadvisable to change the hourly ephemeris of the *Moon* for δT until it has been well established by further observations.

A new attempt has been made to analyze these minor fluctuations since 1750 after the application of the correction δT. A term with a period of about 40 years and coefficient 1″ seems to have persisted during the whole interval, but no single additional term (which must be of longer period) can represent the more extensive part of these minor fluctuations, and if we attempt to analyze with two or more additional terms the number of possibilities becomes great, and gives no security that prediction by means of them will be any better than by extrapolation through inspection. I again call attention to the fact that these fluctuations appear to proceed by sudden rather than gradual changes of the mean motion, the latter remaining nearly constant for some years after the change. The point of this remark consists in the fact that the magnitude of the force required to pro-

** *Monthly Notices*, Vol. 73, pp. 703-6.

†† *Report of the Astronomer Royal*, 1921, p. 7.

Date	B-H	δT	O	Th-O
				″
1900.5	+3.10	+1.53	−2.69	−4.94
1.5	2.94	1.63	2.77	1.80
2.5	2.73	1.73	3.45	1.34
3.5	2.71	1.83	3.08	1.46
4.5	3.29	1.93	3.46	2.06
5.5	3.54	2.04	5.29	−0.29
6.5	3.13	2.15	5.94	+0.63
7.5	2.75	2.26	5.96	0.95
8.5	3.00	2.38	5.97	0.59
9.5	3.46	2.49	6.41	0.46
1910.5	3.67	2.61	7.85	1.57
11.5	3.97	2.73	8.34	1.64
12.5	4.92	2.86	9.79	2.04
13.5	5.80	2.98	11.93	3.15
14.5	5.88	3.11	12.86	3.87
15.5	5.74	3.24	12.58	3.63
16.5	5.95	3.38	14.05	4.72
17.5	5.92	3.52	14.03	4.59
18.5	5.47	3.66	14.05	4.92
19.5	5.40	3.81	12.26	3.35
1920.5	5.05	3.96	−13.11	+4.10
21.5	4.84	4.11		
22.5	+4.63	4.26		
23.5		4.42		
24.5		4.57		
25.5		4.73		
26.5		4.89		
27.5		5.06		
28.5		5.22		
29.5		5.39		
1930.5		5.56		
31.5		5.74		
32.5		5.92		
33.5		6.10		
34.5		6.28		
35.5		6.47		
36.5		6.66		
37.5		6.85		
38.5		7.05		
39.5		7.24		
1940.5		+7.44		

duce the change is independent of the mode of representation: it is, in fact, proportional at any time to the *curvature* of the curve which represents the deviations of the *Moon* from its predicted place. Thus the great empirical term is the result of a much smaller force than that which produces the minor fluctuations, because its curvature is always small compared with that which at times is exhibited by the latter.

Errata in the New Tables

The following errata have been kindly sent by Dr. Cowell, Professor Hirayama, Dr. P. Blum, and Mr. Bawtry. Only one of them, the last, occurs in the tables used for computation: the others are errors in the explanatory matter given in the Introduction.

Sect. I, p. 36, lines 5, 6: *interchange* 23, 24.

p. 44, lines 5, 6, 20 and on p. 82: *for* Args. 70, 71 *read*, Args. 71, 72, respectively.

p. 97: *for* $-\dfrac{n-1}{4}(\Delta'' + \Delta'')$

read $+\dfrac{n-1}{4}(\Delta'' + \Delta'')$

p. 97: in the computation of Σ_3 column 1.5, drop the number 44 one line down.

p. 98 first block: in the argument III, 23 *for* $0^d.0$ *read* $9.^d0$.

p. 99: in the computation of Σ_6, *for the last argument* 6 *read* 16.

p. 102, line 11: *for* 82, 83, 84 *read* 79, 80, 81.

p. 102, line 26: *insert* Σ'_{13}.

p. 109, examples: *for* 1923, $6^d.0$ *read* 1923, $9^d.0$.

p. 109, examples: *for* $-1°\,36'\,27''.87$ *read* $+1°\,36'\,27''.87$.

Sect. VI, p. 94, Arg. $4°\,33'\,10''$: *for* 5419 *read* 5409.

On p. 95, Sect. I, the argument denoted by $92 - l'$ in several places in the illustrative example has caused confusion. It was intended to mean the value of arg. 82 at the time when $l' = 0$. Its value on day 0 is 5206 and on day 2.52, when $l' = 0$, 5209. A similar remark applies to the arguments on the same page denoted by $78 - l'$, $83 - l'$, $84 - l'$.

There has also been some doubt as to the constants used in the actual tables. These are given on pp. 80, 81 of Sect. I. In particular the adopted constant of *sine-parallax* is 3422″.54, corresponding to a constant of *parallax* of 3422″.70.

Yale University, 1922, February 21.

CONTENTS.

Editor, Benjamin Boss, Albany, N. Y.; Associate Editors E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward.
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STELLAR PARALLAXES DERIVED FROM PHOTOGRAPHS,

MADE WITH THE 60-INCH REFLECTOR OF THE MOUNT WILSON OBSERVATORY,

BY A. VAN MAANEN.

The following table, giving a summary of the results obtained from the Mount Wilson parallax work, is a continuation of the lists published in *Astronomical Journal*, Nos. 723 and 755. The full details for the individual objects are to be found in "The Photographic Determination of Stellar Parallaxes with the 60-inch Reflector," fifth series (Mount Wilson Contributions, No. 204), and sixth series (in press).

The table is self-explanatory. The magnitudes are taken from the *Revised Harvard Photometry*, except when stated otherwise in the footnotes. The spectra have been determined by MR. ADAMS, except those marked by an asterisk, which are from the *Revised Harvard Photometry*. The proper-motions are from BOSS's *Preliminary General Catalogue*, or from PORTER's *Catalogue of Proper Motion Stars*.

The values in the seventh column are relative parallaxes: to convert them into absolute parallaxes 0''.001[5] should be added.

The mean probable error of a parallax is 0''.0057; the mean number of exposures is 16.3; the mean number of comparison stars is 7.9.

Object	α 1900	δ 1900	Mg.	Sp.	μ	π	P. E.	No. Exp.	No. Comp. stars
	h m s	° '			"	"	"		
N. G. C. 40 (1)	0 7 35	+71 58	11.6	Pl. Neb.		+0.003	0.003	18	8
T Cassiopeiae	0 17 48	+55 14	var.	Md	.	+0.027	0.003	18	8
Lalande 1966	1 3 18	+61 1	7.8	F5	0.638	+0.015	0.004	16	8
P. G. C. 394	1 40 30	+63 22	5.74	Ko	0.634	+0.118	0.007	16	8
P. G. C. 500	2 6 57	+50 36	5.40	G5	0.386	+0.011	0.005	16	7
R Trianguli	2 31 0	+33 50	var.	Md	..	+0.005	0.005	18	7
P. G. C. 654	2 47 24	+37 56	5.32	Fo	0.099	+0.027	0.009	16	8
Lalande 6888	3 40 12	+41 9	8.4	Ko	1.372	+0.076	0.005	16	8
Lalande 6889	3 40 12	+41 9	8.8	K2	1.372	+0.081	0.006	16	8
N. G. C. 1501 (1)	3 58 23	+60 39	13.0	Pl. Neb.	.	+0.016	0.003	16	7
N. G. C. 1514 (1)	4 3 0	+30 31	8.0	Pl. Neb.		+0.012	0.009	16	7
Anonymous (2)	4 53 11	+39 13	13.2	......	0.377	+0.010	0.005	16	8
RX Aurigae	4 54 28	+39 49	var.	F9p		−0.001	0.005	16	8
N. G. C. 2022 (1)	5 36 37	+ 9 2	14.2	Pl. Neb.		+0.008	0.004	16	10
P. G. C. 1604	6 16 54	+22 34	3.19	Ma (G6)	0.128	+0.007	0.005	16	9
P. G. C. 1676	6 29 40	+38 32	5.87	N	0.036	+0.003	0.002	16	7
N. G. C. 2261 (1)	6 33 34	+ 8 49	13.8	Var. Neb.		−0.010	0.004	14	8
N. G. C. 2371-2 (1)	7 19 18	+29 41	13.5	Pl. Neb.		+0.011	0.005	16	9
R Cancri	8 11 0	+12 2	var.	Md	.	−0.001	0.004	16	7
P. G. C. 2573	9 29 40	+36 16	5.18	K1	0.753	+0.066	0.005	16	7
W Ursae Majoris	9 36 42	+56 25	var.	F8p		+0.023	0.006	14	6
P. G. C. 3145	11 57 21	+43 39	6.83	G7	0.629	−0.013	0.006	16	8
N. G. C. 4051 (1)	11 58 7	+45 6	13.8	Sp. Neb.	...	+0.001	0.005	16	7

Object	α 1900	δ 1900	Mg.	Sp.	μ	π	P. E.	No. Exp.	No. Comp. stars
	h m s	° ′			″	″	″		
R Virginis	12 33 26	+ 7 32	var.	Md		+0.010	0.004	16	6
P. G. C. 3322	12 40 24	+15 58	5.53	N	0.006	−0.002	0.003	16	8
P. G. C. 3554	13 12 0	+ 6 54	6.32	F9	0.499	+0.026	0.007	16	8
R Canum Ven.	13 44 39	+40 2	var.	Md		−0.010	0.002	14	7
P. G. C. 3785	14 15 14	+38 13	5.98	F2	0.276	+0.014	0.008	16	7
P. G. C. 4054	15 51 18	−13 26	5.54	Ma (G8)	0.075	+0.034	0.003	18	8
Lalande 29137	16 1 16	+ 6 40	6.02	Ko	0.760	+0.026	0.005	16	8
N. G. C. 6210 (1)	16 40 18	+23 59	11.7	Pl. Neb.	. .	−0.003	0.003	16	8
U Ophiuchi	17 11 27	+ 1 19	var.	B8	. . .	+0.012	0.008	16	8
P. G. C. 4518	17 18 49	+40 0	6.06	F5[3]	0.054	+0.014	0.009	18	6
N. G. C. 6543 (1)	17 58 32	+66 38	11.3	Pl. Neb.	. . .	+0.029	0.004	16	9
N. G. C. 6572 (1)	18 7 14	+ 6 50	10.8	Pl. Neb.	. . . .	+0.003	0.009	16	8
X Ophiuchi	18 33 34	+ 8 45	var.	Md	. . . .	0.000	0.007	16	9
Nova Aquilae, No. 3	18 43 49	+ 0 29	var.	Nova	. . . .	+0.019	0.006	16	9
17 *Lyrae* C (3)	19 3 40	+32 21	11.00	Ma	1.705	+0.109	0.008	16	8
P. G. C. 4963	19 21 45	+12 49	5.77	F[8]	0.066	+0.024	0.008	16	8
RR Lyrae	19 22 14	+42 36	var.	Fop	. .	+0.006	0.006	20	9
B. D. +30° 3639 (1)	19 30 54	+30 18	10.2	O	. . .	+0.005	0.009	16	9
Groombridge 3215	20 29 20	+44 33	7.04	Ko	0.175	+0.050	0.004	18	8
P. G. C. 5309	20 34 52	+29 59	5.86	Ko	0.090	+0.014	0.006	16	7
N. G. C. 7026 (1)	21 2 55	+47 27	15.4	Pl. Neb.		+0.014	0.008	16	8
P. G. C. 5614	21 44 28	+60 14	5.64	K5	0.006	+0.019	0.006	16	8
P. G. C. 5694	22 3 47	+58 24	6.34	G6	0.030	+0.015	0.005	18	7
P. G. C. 5719	22 8 7	+58 55	5.19	Od[2]	0.023	+0.010	0.004	16	8
Pi. 22h 214	22 40 55	+29 56	6.52	Ko	0.464	+0.027	0.007	16	8
P. G. C. 6020	23 18 52	+31 59	6.53	A9	0.233	+0.014	0.008	16	9
Pi. 23h 164	23 38 32	+57 34	7.3	G2	0.610	+0.028	0.009	20	8
Pi. 23h 267	23 59 39	+34 6	6.23	G1	0.766	+0.009	0.009	16	8

1 The magnitudes for the central stars of the nebulae are photographic, derived from counts of the number of stars of equal and brighter magnitude and are based on Table IV of *Groningen Publications*, No. 27.

2 The magnitude of this star was derived as in note 1; the proper-motion was found by VAN MAANEN in deriving the parallax of Boss 4182.

3 The magnitude and proper-motion are taken from BURNHAM's *Measures of Proper Motion Stars*.

Mount Wilson Observatory,
February, 1922.

PRESENT CORRECTIONS TO THE *MOON'S* LONGITUDE.

By E. B. TUSTIN, JR.

In *A. J.* 734 the writer deduced from occultations several empirical terms of mean period applicable to the *Moon's* mean longitude. These terms represented the minor residuals of NEWCOMB's empirical term over a period of 65 years, with a mean error of 0″.83; within that of any single minor residual group comprising the data used. Five years have elapsed since the formula was derived and it seems desirable to compare it now with the most modern and best observations.

What we propose to accomplish in the present paper is:

(a) To find the present correction to the *Moon's* mean longitude.

(b) To compare this observational correction with the formula for correction mentioned above.

The occultations used for this purpose are selected from 18, privately submitted by courtesy of Capt. W. D. MacDougall, Naval Observatory. Of these 18, 7 were judged as being entitled to weights great enough for our purpose, upon considering the comments of the observers. An occultation was rejected when the error in time as indicated by the observer was greater than $0^s.5$, or where the observation was made through clouds, trees, or, in general, wherever uncertainty in time was implied. *RB* phase was not used on account of the well known errors pertinent to this class of observations. *DB* phase was used only when the same phenomena was noted independently by two observers. Regard was also had for the fact that the best determination of longitude correction obtains when the angle reckoned on the *Moon's* limb from vertex to star is not too far from 90°. This preliminary selection saves us the labor of reducing obviously uncertain observations, while at the same time we do not greatly diminish the weight of the result.

The occultations were reduced by the method of Newcomb as given on page 20, *Researches on the Motion of the Moon, Papers of the American Ephemeris*, Vol. IX, Part 1. Page numbers in the present paper refer to Newcomb's work.

In the following table, s' is the apparent semidiameter of the *Moon*; D, the distance of centers as computed from Hansen's tables as used in the *American Ephemeris*; $\Delta\beta'$ the orbit latitude correction applicable to Hansen's tables; m', the position angle of star corresponding to the plane of the *Moon's* orbit; and F, the factor for reducing the correction of the mean longitude to that of the true (page 25).

$\Delta\beta = +0''.68$, (p. 38, 223), can be taken with sufficient accuracy as perpendicular to the *Moon's* orbit, and used for $\Delta\beta'$.

Minor residuals =

$$r = \frac{(s' - D) - \Delta\beta' \cos m'}{F \sin m'} - (\text{Newcomb} - \text{Hansen}).$$

Date 1921	Star	Ph.	W. Sid. T.	W. M. T.	Seeing	Power	Obs.	Rem.	Δλ (Newcomb —Hansen)	Δπ	(s′−D)	Δβ′ cos m′	r
			h m s	h m s		″			″	″	″	″	″
Aug. 10	ζ *Libræ*	DD	19 5 31.9	9 49 23.2	*p*	183–26	B	4	+5.99	+0.11	− 7.03	−0.51	+4.26
Oct. 15	171 *B Piscium* .	DD	5 41 13.0	16 3 50.1	*f*	183–26	Hl	. .	3.91	0.40	−10.12	−0.38	8.42
			5 41 13.1	16 3 50.5	*p*	? 12	B	7					
20	115 *Tauri*	RD	6 23 59.2	16 26 50.1	*p*	183–26	Hl	4	4.84	0.44	+ 8.66	+0.54	8.07
21	292 *B Orionis*	RD	4 8 5.6	14 7 22.7	*f*	183–26	Hl	. .	4.92	0.44	+12.85	+0.27	8.17
			4 8 5.7	14 7 22.9	*f*	115–12	B	9					
22	λ *Geminorum* . .	DB	2 14 2.2	12 9 42.2	*f*	183–26	Hl	. .	5.07	0.44	−14.00	−0.16	8.46
			2 14 2.6	12 9 42.5	*f*	160–12	B	10					
22	λ *Geminorum* . .	RD	3 17 36.7	13 13 6.2	*f*	183–26	Hl	9	5.07	0.14	+15.86	−0.05	10.06
			3 17 36.8	13 13 6.3	*f*	115–12	B	7					
Dec. 15	26 *Geminorum* .	RD	7 18 48.4	13 41 19.4	*f*	183 26	Hl	9	+4.31	+0.46	+12.88	+0.14	+7.49
			7 18 48.4	13 41 19.4	*f*	160 12	B	4					

Rem: (4) Late $0^s.1$; (7) Late $0^s.15$; (9) Late $0^s.2$; (10) Late $0^s.3$.

To determine the best value of r, we premise that up to a certain limit e_o the weights of the individual values of r should not be diminished on account of their discordance from a simple mean of the accordant values of r. The question will arise as to the law of diminution of the weight when the residual error exceeds e_o. This implies that the weight for a discordant observation above e_o is made to depend upon its variation from other observations which do not include the discordant; but this proceeding is rigorously logical when properly applied.*

Let us put for Δ the excess of the error above the limit e_o. This is applicable in the present case to each of the two observations No. 1 and No. 6. Then we propose to determine their separate weights by the condition

$$w = \frac{e_o}{e_o + \Delta} \qquad (1)$$

We will have the same result, practically, that this equation will lead to if we substitute for each actually observed discordant quantity other separate quantities corresponding to the residual e_o. In other words, instead of finding a mean result by weights, we change two of the quantities comprising the final mean and use the weight 1. This is readily done by remembering that, from what has been said,

* Chapter XI.

$$\text{Preliminary Mean } r - \text{Discordant } r = e_o + \Delta, \quad (2)$$

where e_o *and* Δ have the same sign.

Now, by using the weight 1, Δ disappears by the formula for w, and we have, from the equation just written, the value of a new quantity used to replace each discordant r, respectively; and corresponding to e_o:

$$\begin{matrix}\text{Replacement for} \\ \text{discordant } r\end{matrix} = \text{Preliminary Mean } r - e_o, \quad (3)$$

having respect for the sign of e_o to be determined from (2).

There is still, of course, a certain amount of indetermination because the limit e_o is a matter of judgment. But the influence of the judgment is much less than what results from continuing the usual fashion of treatment. The computer is relieved of the guesswork attending the acceptance or rejection of doubtful values of r. In the present case I have used $e_o = \pm 1'' = $ p. e., based to a certain extent on the quality of the observations used, however the resulting value of r would have been almost identical with that obtained even if a greater value of e_o had been taken.

By this procedure we deduce:

$$r, (1921.8) = +8''.1, \quad \text{p. e. } 1''.0.$$

Empirical terms for the minor residuals are, (*A. J.* 734)

$$\begin{aligned} r = &+1''.09 + 7''.30 \sin (86^\circ + 5^\circ.7t) \\ &+4''.03 \sin (242^\circ + 7^\circ.1t) \\ &+0''.50 \sin (249^\circ + 17^\circ.4t). \end{aligned}$$

$$m.\,e. = 0''.83 \qquad t = (T - 1850.5)$$

For the mean date of the observations given above the terms give

$$r = +8''.6,$$

which is in close agreement with r as deduced from the present observations, and well within its probable error.

Correction to the *Moon's* true longitude in orbit (as computed from HANSEN's tables plus corrections used in the *American Ephemeris* since 1883), is given at any time by the following:

$$\Delta v = F(r) + \underset{46}{(dl + h \sin g + k \cos g)}$$

$$+ F(\underset{203,\ 210,}{\Delta Th + \Delta N_2} + \underset{210.}{\text{NEWCOMB's Long Period Term}}),$$

while the correction to be applied to the ecliptic latitude is

$$\Delta\beta = +0''.68 + \sin i \cos (v - \Omega)\, \Delta v.$$

The results of this paper appear to substantiate the writer's deduction in *A. J.* No. 734 that at least two new periodic terms in the mean longititude, with coefficients of approximately 7″ and 4″ respectively, in addition to NEWCOMB's term of long period, are needed in the Lunar Theory to account for the anomalies in the *Moon's* motion.

Ocean Grove, N. J.,
February, 1922.

A COMPARISON OF PROPER-MOTIONS,

OBTAINED BY PHOTOGRAPHIC MEASURES AND MERIDIAN OBSERVATIONS,

By J. G. PORTER.

In the *Monthly Notices* of the Royal Astronomical Society, Volumes LXIX, LXXI, and LXXII, are several lists of proper-motions derived from comparison of photographic plates, the intervals being in general between ten and twenty years. Eighteen of these stars occur in BOSS's *Preliminary General Catalog*. Most of the remaining stars which are bright enough to be included in the *A. G. Catalogs* were observed at Cincinnati, and their proper-motions determined from all the meridian data obtainable. A comparison of the Boss and Cincinnati motions with those derived from the photographic plates is here given. The average difference between the Boss and M. N. motions is 0″.051, and between the Cincinnati and M. N. motions 0″.05, while over 12 per cent of the stars differ by 0″.1 or more.

If a few cases the meridian observations do not furnish sufficient data to render the motions very reliable; but I believe that with few exceptions these results are entitled to much more weight than the photographic motions. Other comparisons of photographic and meridian work have led me to a similar

conclusion. I do not wish to be considered as disparaging photographic work: much of its is no doubt of the highest excellence. But in view of the fact that the tendency now is to let photographic measures supersede just as far as possible meridian observations, a note of warning will not be out of place. It is for this reason that I am publishing this comparison.

The numbers in the first column refer to the Cambridge (C) or the Berlin B (B) A. G. catalogs. A figure 2 in parentheses after the M. N. motion signifies that there are two determinations, the mean of which is given. The proper-motions taken from Boss are indicated by B.

A.G. No.	R.A. 1900	Decl. 1900	Proper-motion M. N.	Proper-motion Ci. or B.
	h m s	° ′	″	″
C25	0 04 02	+25 29	0.18	0.16
C93	10 50	25 17	0.18	0.14
C370	33 16	28 46	0.228	0.337B
B293	51 55	24 45	0.188	0.201
B313	56 19	24 45	0.113	0.132
C732	1 11 12	25 55	0.27	0.23
C735	11 21	25 32	0.14	0.06
B405	15 35	24 38	0.136	0.150
C799	19 34	26 01	0.18	0.03
B490	31 51	24 40	0.277	0.337
C934	35 44	25 14	0.119	0.134B
C1028	48 18	25 17	0.132	0.116
C1074	52 21	26 00	0.13	0.09
C1181	2 07 41	24 55	0.14	0.18
C1758	3 31 10	25 40	0.354	0.355
C2023	4 08 27	26 00	0.18	0.12
C2118	30 36	26 56	0.249	0.241
C2212	52 08	25 56	0.22	0.13
B1593	54 20	24 01	0.13	0.04
B1602	55 31	24 30	0.297	0.322
C2321	5 03 14	27 31	0.20 (2)	0.14
C2322	03 47	27 26	0.219 (2)	0.226
C2330	04 36	25 01	0.16	0.22
C2334	04 50	25 50	0.14	0.16
C2344	06 10	26 20	0.19	0.16
C2460	20 35	24 55	0.17	0.07
C2575	33 32	25 50	0.173	0.044B
B2077	51 52	24 36	0.16	0.04
C2846	54 03	25 11	0.15	0.08
C2925	58 54	25 18	0.15	0.00
C3090	6 10 29	25 15	0.42	0.48
C3261	22 33	25 11	0.21	0.16
B2526	35 08	24 03	0.30	0.34
C3636	6 52 38	+26 13	0.195	0.183B
C3816	7 06 39	29 28	0.15	0.04
C3834	07 19	25 14	0.399	0.451
C3862	10 17	27 01	0.15	0.02
C3880	12 15	27 26	0.17 (2)	0.21
C3954	19 31	28 00	0.215	0.115B
C3991	24 05	29 36	0.24	0.24
C4379	8 02 55	24 56	0.30	0.42
C4397	04 26	25 49	0.373 (2)	0.361B
C4398	04 35	25 00	0.13	0.14
C4482	8 13 59	27 32	0.351	0.389B
C4498	16 25	26 57	0.16	0.09
C4505	17 35	25 29	0.24	0.18
C4732	49 00	26 35	0.39	0.44
C4794	56 38	26 17	0.235	0.230
C4838	9 02 54	27 03	0.368	0.403B
C4860	06 04	25 29	0.23	0.25
C4873	08 09	26 35	0.15	0.10
C4921	15 22	25 35	0.181	0.160B
C5010	28 07	24 42	0.23	0.18
C5029	30 54	27 03	0.15	0.13
B3836	40 14	24 14	0.175	0.047B
C5173	53 35	28 00	0.34 (2)	0.34
C5179	54 25	25 02	0.276	0.242
C5229	10 03 45	25 02	0.14	0.19
B3953	06 16	24 15	0.411	0.414
B3974	14 00	24 00	0.210	0.209B
C5280	14 19	26 22	0.31	0.34
C5285	14 45	28 34	0.25 (2)	0.26
C5365	22 46	25 24	0.18	0.24
C5407	29 15	28 29	0.198	0.195
C5424	31 51	25 36	0.16	0.16
C5565	51 45	25 18	0.17	0.12
C5593	10 55 36	+24 36	0.16	0.20
C5620	59 55	25 15	0.416	0.409B
C5764	11 22 17	24 36	0.19	0.22
C6020	12 06 11	25 19	0.11	0.10
C6079	16 03	25 35	0.250	0.252
B4514	20 13	24 29	0.118	0.072B
C6120-1	22 13	27 35	0.24	0.24
C6241	41 38	24 12	0.256	0.234
C6253	43 55	25 23	0.301	0.367
B4698	13 02 54	24 32	0.27	0.27
B4702	03 15	23 57	0.13	0.13
B4707	04 27	24 26	0.14	0.24
C6430	14 06	25 08	0.30 (2)	0.32
B4783	21 41	24 05	0.261	0.174
C6514	28 01	24 52	0.218	0.222
B4838	33 36	24 05	0.19	0.23
C6552	34 14	24 15	0.12	0.03
C6582	39 30	25 17	0.11	0.12
C6624	47 17	25 32	0.12	0.14
C6651	51 19	25 01	0.19 (2)	0.21
C6659	52 25	25 25	0.18	0.18

A.G. No.	R.A. 1900	Decl. 1900	Proper-motion M. N.	Proper-motion Ci. or B.
	h m s	° ′	″	″
C6814	14 18 38	25 47	0.150	0.157
B5072	21 05	24 06	1.33	1.39
B5073	21 08	24 06	1.42	1.40
C6818	23 47	24 58	0.257	0.268
C6900	31 23	25 23	0.17	0.11
B5110	31 46	24 25	0.12	0.09
C6914	33 21	28 35	0.22	0.17
B5130	36 50	24 09	0.14	0.23
C6937	37 03	29 29	0.21	0.16
C6963	42 03	28 19	0.18	0.19
C6976	43 57	24 47	0.161	0.118
B5182	45 47	24 19	0.180	0.143
B5215	56 52	24 15	0.16	0.07
C7081	15 02 55	25 16	0.188	0.262B
C7086	03 08	25 18	0.995	0.961
C7136	12 25	25 35	0.24	0.26
C7155	14 45	26 04	0.565	0.568
C7169	16 52	25 56	0.16	0.11
C7256	30 32	25 20	0.14	0.15
C7468	59 55	25 31	0.922	0.862
C7703	16 29 12	25 54	0.29	0.24
C7959	58 13	25 39	0.128	0.108
C7969	16 58 50	+25 47	0.15	0.13
B5859	17 03 38	24 43	0.14	0.05
B5874	06 31	24 39	0.33	0.31
C8114	13 16	25 08	0.11	0.15
C8165	18 21	24 59	0.183	0.205
C8236	25 29	29 29	0.33	0.39
C8455	45 09	24 54	0.14	0.05
C8592	56 48	29 34	0.137	0.213
C8623	58 17	28 27	0.14	0.03
C8634	59 37	29 34	0.14	0.11
B6349	18 08 25	24 26	0.10	0.03
B6570	33 03	24 21	0.10	0.15
B6868	19 05 01	24 10	0.12	0.07
B6925	12 00	24 36	0.16	0.19
C9797	13 45	25 11	0.276 (2)	0.270
B6940	14 01	24 14	0.144	0.158
B7012	21 17	24 14	0.697	0.658B
C10001	23 38	26 00	0.15	0.13
B7046	24 33	24 28	0.151	0.170B
B7229	38 54	24 22	0.27	0.26
C10372	41 40	26 50	0.15	0.14
C10423	43 56	27 37	0.25	0.23
C10636	52 48	29 16	0.22	0.22
C10637	52 50	29 41	0.19	0.19
C10644	53 10	29 40	0.24	0.23
C10646	53 12	29 33	0.32	0.26
C10724	56 45	29 33	0.13	0.13
C11508	20 31 25	25 02	0.25	0.37
C11658	39 02	25 28	0.15	0.02
C11904	50 46	27 43	0.197	0.114
C12058	59 14	25 09	0.17	0.20
C12832	21 39 31	26 56	0.38	0.33
C12834	39 38	26 04	0.21 (2)	0.21
C12835, *m*	39 40	28 17	0.312	0.345B
B8366	39 41	24 53	0.68	0.65
C12922	44 32	26 02	0.17	0.00
C12951	46 33	28 42	0.24	0.26
C12981	49 26	27 52	0.220 (2)	0.217
C13020	51 47	25 58	0.21 (2)	0.18
C13179	22 01 21	27 29	0.16	0.21
B8525	02 21	24 51	0.204	0.300B
C13283	08 34	25 27	0.234	0.164
C13492	25 19	25 26	0.143	0.125
C13650	22 37 14	+27 07	0.16	0.12
C13664	38 57	29 34	0.225	0.226
C13673	39 27	28 09	0.16	0.05
C13684	40 50	30 02	0.18	0.06
C13685	40 55	29 56	0.445	0.461
C13716	43 48	28 12	0.18	0.19
C13727	44 33	29 34	0.15	0.04
B8876	23 06 11	24 10	0.15	0.14
B8904	11 02	24 14	0.141	0.092
C14030	14 59	28 19	0.75	0.66
C14057	17 10	28 09	0.149	0.129
C14090	21 11	28 14	0.13	0.09
C14091	21 41	28 29	0.15	0.13
C14376	52 59	29 25	0.18	0.14

Cincinnati Observatory,
Feb. 8, 1922.

ADDENDUM TO A. J. NO. 797.

Professor Hertzsprung has called to my attention that the faint member of the *Taurus* Group discussed in the *Journal, loc. cit.*, had earlier been recognized by Kapteyn and De Sitter as probably belonging to the group. My note must therefore be regarded as confirming their suggestion and considerably amending their value of the proper-motion.

George C. Comstock.

April 25, 1922.

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DIFFERENTIAL REFRACTION IN POSITIONAL ASTRONOMY,

By WILLIAM B. VARNUM.

Early in the nineteenth century meridian observers noticed certain systematic errors in star positions which were ascribed by BESSEL and DEBALL, among others, to variation in refraction, apparently of a seasonal nature. Little was done, however, to determine the nature and amount of these errors until the latter part of the century, when LEWIS BOSS, AUWERS, and NEWCOMB, in forming their fundamental systems of positions, recognized the existence of systematic errors dependent upon right-ascension, the seasonal effect, and upon declination. Various suggestions were made as to the physical causes of these errors but, owing to the difficulty in defining the effects of the various sources of error on the observations, it became the common practice to eliminate them, as far as possible, by proper combinations of observations and by means of systematic corrections derived from comparison with a fundamental catalog upon the assumption that the systematic errors had been eliminated, or at least materially reduced, in the formation of the fundamental catalog by the combination of observations from various sources, taken with different instruments, under widely differing conditions and reduced by different methods. Thus were introduced into Positional Astronomy the well-known corrections $\Delta\alpha_\alpha$, $\Delta\alpha_\delta$, $\Delta\delta_\alpha$, and $\Delta\delta_\delta$. The two terms dependent upon α have the form $(a \sin\alpha + b\cos\alpha + c\sin 2\alpha + d\cos 2\alpha)$.

In seeking an explanation of the Kimura term in the variation of latitude Ross (1) suggested in 1912 the possibility of a "secular refraction starting at sunset" or a seasonal refraction effect of the form

$$r = \alpha + \beta\cos\odot + \gamma\sin\odot$$

In the same year TUCKER (2) published a discussion of the position of the mire at Mt. Hamilton deriving a set of empirical corrections necessary to reduce the observations of the early hours of the night to a standard value. In 1913 the same writer (3), in a paper on "Diurnal Variation of Refraction at Mt. Hamilton," established a difference in the effect of refraction between daytime and night observations, which might be expressed in terms of a correction of the Pulkova refraction constant. In his paper he says, "This difference does not depend upon barometric pressure, nor upon temperature nor upon the changes of temperature during the observing hours." Yet, later in the article, he offers a possible explanation of the phenomenon on the basis of the difference in the effects of temperature changes on the upper and lower air strata and notes that this supposition would bring daytime refractions into closer accord with the night.

In the same year the author found a similar diurnal term in the clock corrections derived from the 12-hour and 24-hour groups of stars at San Luis. In the Year Book of the Carnegie Institution of Washington for 1913 are given the values of this term for each hour of the day, for each of the four seasons of the year, and the mean values for the twenty-two months of observing at San Luis. In discussing these observations there did not seem to be sufficient justification for attempting to eliminate this term as the Rieller clock was not under control. When, however, the same term was found in clock corrections derived from the Albany observations where the new Reifler clock was running under perfect control, it appeared that the diurnal effect could not be due to the clock. This belief was strengthened by finding the same phenomenon in the Greenwich observations of 1907-8, where two clocks were employed; in the Pulkova observations of 1891-6, where, also, two clocks were used; and in the Cape 1900 observations. The results of these tests of observations made at other observatories were published in the Year Book of the Carnegie Institution for 1920. The same effect has been noted by TUCKER at Mt. Hamilton and by EICHELBERGER at Washington where at least two clocks were used. Thus, in the observations of seven widely-separated institutions employing at least ten different clocks the

[1] *Astronomische Nachrichten 192*, 112, 1912.
[2] *Lick Observatory Bulletin 7*, 41, 1912.
[3] *Lick Observatory Bulletin 7*, 130, 1913.

same term has been found. It has been customary, heretofore, to ascribe the diurnal effect in declination to variation in refraction and that in transits to the clock. There appear to be no series of observations which are sufficiently inclusive to form the basis for a general discussion of the diurnal effect other than those of San Luis and Albany. In these two series, morning, afternoon, and night observations are made of all stars bright enough to be visible with sky illumination. Not being confined to a few selected stars, and those stars observed on selected dates, our observations are free from personal bias and give a true representation of the diurnal phenomenon. In the following tables are exhibited the form and values of this term for various combinations and stations.

In Table A are given the seasonal values of the term, together with the mean from all for the San Luis station. The first column gives the values derived from the curves while the second gives the computed values expanded by the formula given below. There can be no doubt that a sin MT + cos MT + sin 2 MT + cos 2 MT formula fits the curves very closely. In

TABLE A

DIURNAL TERM IN TRANSITS

San Luis Reifler No. 88

M T	Mar.–May Curve	Mar.–May Comp.	June–Aug. Curve	June–Aug. Comp.	Sept.–Nov. Curve	Sept.–Nov. Comp.	Dec.–Feb. Curve	Dec.–Feb. Comp.	Mean Curve	Mean Comp.
h	s	s	s	s	s	s	s	s	s	s
0	+0.004	+0.008	+0.018	+0.019	+0.012	+0.010	+0.028	+0.033	+0.016	+0.018
1	+ 6	+ 10	+ 25	+ 25	+ 13	+ 14	+ 31	+ 37	+ 19	+ 21
2	+ 8	+ 14	+ 30	+ 28	+ 14	+ 17	+ 34	+ 40	+ 22	+ 24
3	+ 10	+ 10	+ 32	+ 28	+ 16	+ 19	+ 39	+ 36	+ 24	+ 24
4	+ 14	+ 10	+ 27	+ 25	+ 18	+ 19	+ 41	+ 32	+ 26	+ 22
5	+ 14	+ 9	+ 13	+ 20	+ 19	+ 17	+ 37	+ 26	+ 21	+ 18
6	+ 10	+ 7	+ 6	+ 14	+ 19	+ 14	+ 19	+ 21	+ 14	+ 14
7	+ 4	+ 6	+ 13	+ 8	+ 12	+ 10	+ 5	+ 15	+ 8	+ 9
8	+ 4	+ 6	+ 8	+ 2	+ 2	+ 5	+ 4	+ 9	+ 4	+ 5
9	0	+ 5	− 2	− 2	− 10	0	+ 7	+ 4	− 1	+ 2
10	− 3	+ 1	− 6	− 1	− 7	− 1	+ 3	+ 1	− 3	− 1
11	+ 5	+ 3	− 6	− 6	− 3	− 7	− 4	− 7	− 2	− 1
12	+ 8	+ 1	− 7	− 7	− 1	− 10	− 14	− 12	− 4	− 6
13	+ 5	− 1	− 8	− 8	− 6	− 14	− 16	− 17	− 6	− 8
14	− 1	− 1	− 10	− 9	− 9	− 14	− 20	− 25	− 10	− 10
15	− 8	− 6	− 14	− 14	− 12	− 14	− 23	− 25	− 12	− 13
16	− 14	− 8	− 12	− 13	− 14	− 10	− 26	− 26	− 16	− 14
17	− 15	− 9	− 14	− 15	− 13	− 10	− 26	− 25	− 17	− 14
18	− 12	− 9	− 14	− 15	− 12	− 8	− 26	− 21	− 16	− 13
19	− 5	− 7	− 14	− 14	− 8	− 7	− 17	− 13	− 11	− 11
20	0	− 5	− 14	− 10	− 1	− 5	+ 4	− 1	− 3	− 6
21	2	2	5	− 1	0	− 2	+ 16	+ 7	+ 3	0
22	+ 3	+ 1	+ 2	+ 3	+ 1	+ 2	+ 22	+ 9	+ 8	+ 6
23	+0.003	+0.003	+0.010	+0.014	+0.008	+0.007	+0.025	+0.017	+0.012	+0.013

		sin MT	cos MT	sin 2 MT	cos 2 MT
	s	s	s	s	s
Apr.	+0.0019	+0.0083	+0.0033	+0.0003	+0.0028
Jul.	+0.0027	+0.0146	+ .0127	+ .0059	+ .0034
Oct.	+0.0015	+0.0112	+ .0098	+ .0023	− .0013
Jan.	+0.0052	+0.0206	+ .0226	+ .0000	+ .0052
All	+0.0032	+0.0136	+ .0121	+ .0024	+ .0030

Table B are given the mean values for Albany and San Luis for the two Riefler clocks covering the whole period of observation. No. 88 was mounted three times and was never under control: No. 218 was mounted once and was always under perfect control: yet, these four conditions of the clock give similar forms of the diurnal effect. These values, also, correspond well to a single and double sine and cosine formula.

TABLE B

DIURNAL TERM IN TRANSITS

Albany Reiflers No. 88 and No. 218

M.T.	No. 88 1907 — 8 Obs'd	Comp.	No. 88 1911 — 13 Obs'd	Comp.	No. 218 1915 — 18 Obs'd	Comp.	Mean S Luis-Albany Obs'd	Comp.
h	s	s	s	s	s	s	s	s
0.5	.	.			+0.002	+0.001	+0.002	+0.001
1.5	+0.008	−0.005	+0.080	+0.050	+7	+6	+11	+7
2.5	−19	0	.	.	−5	+10	−18	+10
3.5	−3	+8	+47	+19	+4	+12	+5	+12
4.5	+27	+18	+10	+10	+22	+13	+24	+14
5.5	+47	+26	+19	+32	+21	+13	+24	+11
6.5	+63	+33	+21	+17	+13	+13	+20	+15
7.5	−5	+35	+8	+12	+14	+13	+10	+15
8.5	+19	+31	+10	+11	+7	+13	+9	+14
9.5	+15	+20	+19	+13	+13	+13	+14	+11
10.5	+2	+6	+26	+20	+11	+13	+10	+13
11.5	+8	−10	+27	+27	+10	+13	+12	+11
12.5	+1	−23	+24	+31	+17	+12	+12	+9
13.5	−23	−34			+6	+10	+3	+6
14.5	−70	−41		.	+15	+7	+10	+2
15.5	−57	−11	. .		+2	+3	−7	−2
16.5	−32	−37	.		−3	−3	−7	−7
17.5	−31	−28	.	.	−18	−8	−20	−10
18.5	−7	−21	−15	−12	−5	−11	−6	−12
19.5	−7	−13	−22	−15	−12	−14	−12	−13
20.5	−10	−9	+4	−12	−12	−14	−10	−12
21.5	−6	−7	+11	−4	−18	−12	−13	−10
22.5	−0.015	−0.004	+10	+11	−19	−8	−15	−6
23.5		.	−0.018	+0.022	+0.022	−0.003	+0.016	−0.002

	C	sin MT	cos MT	sin 2 MT	cos 2 MT
	s	s	s	s	s
1907-08,	C = −0.0049	+0.0277	+0.0043	−0.0144	−0.0079
1911-13	= + .0201	+ .0158	+ .0015	+ .0187	+ .0110
1915-18	= + .0038	+ .0113	− .0067	+ .0039	+ .0021
1907-18	= + .0034	+ .0129	− .0046	+ .0018	+ .0018

In Table C are given the mean values of the four meteorological co-efficients of the atmosphere. These values are mean annual values for each hour of the day and are compiled from the reports of the New York Meteorological Observatory. The effect, also, of barometer and thermometer on the Pulkova refractions is given. The first column in each group gives the observed value, the second the diurnal term in the observed, and the third the diurnal term computed by the same formulæ used to represent the similar term in the clock-corrections. The diurnal term in zenith-distance, shown in a later table, is of similar form. In other words, the phenomenon found in the observed transits and the observed zenith-distances is of the same form as that shown to exist in the meteorology, a natural phenomenon of the form a sin MT + b cos MT + c sin 2MT + d cos 2MT. Therefore it would seem unreasonable to attribute systematic error in transits to as perfect a piece of mechanism as the modern astronomical clock and to seek a widely different reason for a similar term in zenith-distances. In view of the similarity between the diurnal term in transits and zenith-distances and the diurnal changes in the state of our atmosphere, is it not the most natural course to examine our observations for a refractional effect?

But to find a logical explanation of the diurnal term it is necessary to disregard the conclusions of many writers on refraction, to modify the theory on which all our refraction tables have been based and assume *that there is a varying prismatic effect due to the changes in the strata of our atmosphere.* This may appear rank heresy until the reader has digested the results presented in this paper but, once digested and absorbed, it must appear a very natural and logical explanation for part, at least, of this troublesome phenomenon. It is evidently wrong to assume that the strata of the atmosphere are horizontal with the *Earth's* surface and to neglect the consideration of a changing prismatic effect. In fact, examination of twenty-two series of observations extending over two years leads to the conclusion that the term "Anomalous Refraction" should really be applied to the rare case when there is no change in the prismatic effect of the atmosphere, that this prismatic effect gives rise to a differential of the vertical refraction and affects both our right-ascensions and declinations.

Let PV represent the prime vertical, MN, the meridian, and Z, the zenith. Imagine the atmosphere to be so constituted that, due to causes to be considered later, it produces a changing prismatic effect upon the rays of light from the star and let AB represent the direction of this prismatic displacement. Call μ the index of refraction, as it were, of the air. If μ remained constant we would have just $F\mu$ as a constant correction to the vertical refractions already applied. But we assume that μ varies with the time of day and we call the rate of change of μ, ρ. So we have a second term $F\mu\rho$. As will be seen from the figure, when ρ is positive the star is apparently at Z', while when ρ is minus the star is apparently at Z''. Or, for $+\rho$ the apparent meridian is east of the true MN, the stars transit too early and we have to apply

TABLE C

DIURNAL TERMS IN METEOROLOGY

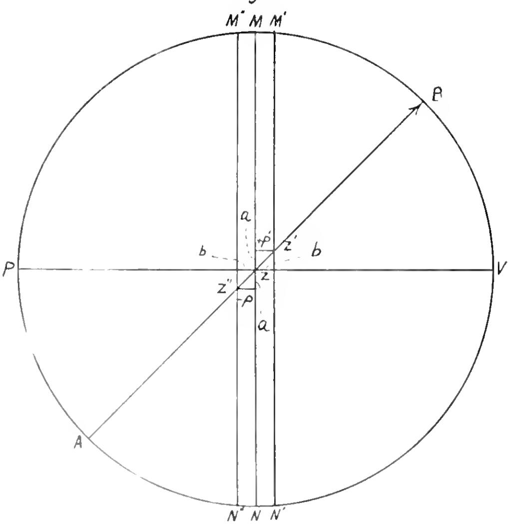
M.T.	Barometer B	Diur	Comp	Shade Temp. T	Diur	Comp.	Hygrometer H	Diur	Comp.
h				°					
0	29.937	+0.007	+0.007	+56.2	+2.2	+2.4	68.0	−1.8	−1.9
1	.922	− 8	− 1	+57.2	+3.2	+3.5	66.0	−6.8	−7.1
2	.913	− 17	− 15	+58.4	+1.2	+1.3	64.5	−8.3	−8.6
3	.907	− 23	22	+58.6	+4.6	+1.6	63.7	−9.4	−9.2
4	.905	− 25	− 26	+58.6	+1.6	+1.5	63.6	−9.2	−8.9
5	.908	− 22	− 24	+58.1	+1.1	+1.0	64.4	−8.4	−7.8
6	.913	− 17	− 18	+57.2	+3.2	+3.1	66.3	−6.5	−6.1
7	.920	− 10	− 10	+56.0	+2.0	+2.2	69.0	−3.8	−4.0
8	.928	− 2	− 1	+55.0	+1.0	+1.2	71.1	−1.4	−1.9
9	.936	+ 6	+ 6	+54.2	+0.2	+0.3	73.2	+0.4	+0.1
10	.936	+ 6	+ 9	+53.6	−0.4	−0.7	74.5	+1.7	+1.8
11	.938	+ 8	+ 8	+53.0	−1.0	−1.3	75.7	+2.9	+3.2
12	.935	+ 5	+ 5	+52.4	−1.6	−1.7	76.9	+1.1	+1.3
13	.930	0	0	+51.9	−2.1	−2.3	77.8	+5.0	+5.2
14	.928	− 2	− 5	+51.4	−2.6	−2.8	78.9	+6.1	+6.0
15	.925	− 5	− 7	+51.0	−3.0	−3.2	79.3	+6.5	+6.6
16	.924	− 6	− 6	+50.6	−3.1	−3.5	79.9	+7.4	+7.1
17	.926	− 4	− 1	+50.4	−3.6	−3.7	80.4	+7.6	+7.3
18	.936	+ 6	+ 7	+50.3	−3.7	−3.7	80.2	+7.4	+7.1
19	.946	+ 16	+ 15	+50.8	−3.2	−3.4	79.2	+6.4	+6.3
20	.951	+ 21	+ 22	+51.7	−2.3	−2.7	77.4	+4.6	+4.9
21	.955	+ 25	+ 25	+52.8	−1.3	−1.7	75.2	+2.4	+2.9
22	.958	+ 28	+ 24	+53.8	−0.2	−0.5	73.5	+0.7	+0.4
23	.950	+0.020	+0.018	+55.0	+1.0	+1.1	70.3	−2.5	−2.3

TABLE C

DIURNAL TERMS IN METEOROLOGY

M.T.	Sun Temp. S. T	Dur.	Comp.	Shade Temp. Relative Refr. Refr.	ρ	Comp.	Sun Temp. Relative Refr. Refr.	ρ	Comp.
h	°	°	°						
0	+89.8	+24.5	+25.8	0.9971	−0.24	−0.23	0.9356	−0.26	−0.15
1	+91.0	+25.7	+26.3	47	− .27	− .15	.9330	+ .25	+ .43
2	+89.4	+24.4	+23.8	20	− .05	− .06	.9355	+ .86	+ .91
3	+84.4	+19.4	+18.6	15	− .01	+ .03	.9441	+1.20	+1.23
4	+77.6	+12.3	+11.7	14	+ .14	+ .12	.9561	+1.50	+1.32
5	+69.4	+ 4.4	+ 4.5	28	+ .16	+ .17	.9711	+1.35	+1.22
6	+62.3	− 3.0	− 2.1	41	+ .25	+ .20	.9846	+ .92	+ .96
7	+57.9	− 7.4	− 7.2	69	+ .22	+ .20	.9938	+ .53	+ .63
8	+55.0	−10.3	−10.5	0.9991	+ .19	+ .18	0.9991	+ .19	+ .32
9	+54.2	−11.1	−12.0	1.0010	+ .12	+ .15	1.0010	+ .12	+ .10
10	+53.6	−11.7	−12.3	22	+ .12	+ .12	.0022	+ .12	.00
11	+53.0	−12.3	−12.2	34	+ .11	+ .10	.0034	+ .11	+ .02
12	+52.4	−12.9	−12.2	45	+ .08	+ .09	.0045	+ .08	+ .10
13	+51.9	−13.4	−12.2	53	+ .09	+ .09	.0053	+ .09	+ .18
14	+51.4	−13.9	−13.6	62	+ .07	+ .08	.0062	+ .07	+ .19
15	+51.0	−14.3	−14.7	69	+ .08	+ .07	.0069	+ .08	+ .07
16	+50.6	−14.7	−15.1	77	+ .04	+ .04	.0077	− .04	− .18
17	+52.0	−13.3	−14.2	81	+ .06	.00	.0073	− .49	− .54
18	+53.5	−11.8	−11.3	87	− .07	− .06	1.0024	− .75	− .93
19	+57.5	− 7.8	− 6.3	80	− .16	− .14	0.9949	−1.34	−1.26
20	+64.6	− 0.7	+ .05	64	− .18	− .20	.9815	−1.71	−1.44
21	+74.0	+ 8.7	+ 8.3	46	− .45	− .26	.9641	−1.66	−1.41
22	+83.2	+17.9	+15.9	25	− .26	− .28	.9478	−1.05	−1.16
23	+87.8	+22.5	+22.1	1.0001	− .34	− .27	0.9373	− .17	− .71

Fig. I



		sin MT	cos MT	sin 2 MT	cos 2 MT
Barometer	Diurnal = +0.0003	−0.0126	+0.0011	−0.0152	+0.0059
Shade Temp.	Diurnal = +0.10	+3.33	+ 2.05	+0.71	+0.28
Hygrometer	Diurnal = +0.09	−6.61	− 4.59	+1.40	−0.40
Sun Temp.	Diurnal = +0.05	+4.58	+18.95	+1.89	+6.75
Shade Temp. ρ	Diurnal = 0.000	+0.133	− 0.159	+0.052	−0.068
Sun Temp. ρ	Diurnal = −0.004	+0.943	− 0.127	+0.653	−0.018

a greater Δt to the transits, while for $-\rho$ the apparent meridan is west of MN, the stars transit too late and we have to apply a smaller Δt to the transits. Similar reasoning will apply to zenith-distances. The distances zz' and zz'' can be resolved into their rectangular coördinates a and b; a is considered the sine component and b the cosine component. The sine component is the shift in zenith-distance and the cosine component, the shift in right-ascension. *The total effect is essentially a shift of the meteorological zenith.*

Now let us consider what will be the effect of this assumption on the observed positions of the stars. Inasmuch as we have already dealt with vertical refraction in the zenith-distances, we will first take up the effect in that coördinate. The "constant" of refraction is not the same for two stations. It is cus-

tomary to apply to our observations a correction of the form

$$\triangle R = \text{True } R - \text{Computed } R_c = CR_c$$

where C is a constant and R_c is the computed refraction. To this we propose to add the differential of the vertical refraction, $dR = x \sec^2 z$, when the second order term is not taken into account. From the results of a preliminary investigation, however, it was found that the second order term became appreciable at low zenith-distance, hence

$$dR_1 = x \sec^2 z \,(1.00232 - .003486 \sec^2 z)$$

or

$$dR_1 = xF' \text{ where } F' = \sec^2 z\,(1.00232 - .003486 \sec^2 z)$$

F' can be tabulated once for all.

The next step is to find some connection between this formula and the state of the atmosphere. Those who have attempted to use a barometric gradient sealed off from a weather map have met with failure as was to be expected, for, as any practical astronomer knows, the rate of change of the barometer has little effect upon the computed refractions. It is the temperature change which is the controlling factor as far as a gradient is concerned. Compare refractions for some barometric gradient on a cold winter night with a hot summer night. The winter night gives an ascending gradient with high refractive power while the summer night gives an ascending gradient with low refractive power, which in itself would produce in our observations a seasonal effect. The *temperature* then, and not the barometer, *is the controlling factor*. However, there is a much better way of using meteorology in connection with refraction. We have already tabulated the corrections to the log μ tan z of Pulkova. We have used them in computing vertical refractions, so they will surely be good enough to compute differential refraction, and the transformation is quite simple.

Let us assume that the Pulkova Tables represent 1.0 times the refraction at standard β and γ. Then applying log corrections, derived from Tables III, V, VII of Pulkova Tables, to the log 1.0 and taking out the natural number corresponding to the resulting logarithm, we get the relative refraction for our station for each period of observation, the value μ. From these relative values of the refraction we can form the hourly differences, or hourly rate of change of the refraction, ρ. In order to refer the ρ's on different nights to the same standard, we form $\mu\rho$. Both μ and $\mu\rho$ will produce a differential effect upon the zenith-distances, so we have as the full formula for investigating the observations

$$dR_1 = e'F'\mu + f'F'\mu\rho$$

The differential refraction will effect the observations with different signs depending on whether north or south zenith-distances are read: that is

for positions AE and BW, $dR_1 = +e'F'\mu + f'F'\mu\rho$
and for positions AW and BE, $dR_1 = -e'F'\mu - f'F'\mu\rho$
the vertical refractions, however, have had their signs changed to conform with tan z, so, if we use the formula with the positive sign, we will come out with $-dR$ for north zenith-distances, and, if we bear this in mind when we come to examine the effect of dR in the mean, we will not be led into error. We thus have for our complete correction, due to the atmosphere, in zenith-distance

$$dR = CR_c + e'F'\mu + f'F'\mu\rho \qquad (1)$$

In the formation of the normal equations $R_c/100$ and $100\ \rho$ were found to be more convenient than R and ρ, and were used.

Using the refractional value of the atmosphere as given for the zenith-distances, the form of the correction for differential refraction in right-ascension is

$$dR = e \cdot \sec z \cdot \sec \delta \cdot \mu + f \cdot \sec z \cdot \sec \delta \cdot \mu\rho$$

or, if we wish to take into account the second order terms,

$$dR = \sec \delta \cdot \sec z (1 - .00116 \sec^2 z)\ (e\mu + f\mu\rho)$$

or, letting

$$F = \sec \delta \cdot \sec z\ (1 - .00116 \sec^2 z)$$
$$dR = eF\mu + fF\mu\rho \qquad (2)$$

which is quite similar to the formula for zenith-distances. Formulæ (1) and (2), then, are the expressions which should be used to correct our observations for the prismatic effect of the *Earth's* atmosphere. The $F\mu$ term is the "drift" for the period under discussion and should account for a large part, if not all, of the Kimura, or z, term in the variation of latitude. It also takes out part of the "seasonal" effect. The $F\mu\rho$ term is the "diurnal" term and also takes out the rest of the "seasonal" effect.

Having thus derived the formulæ for the effect dR will have upon the observations in zenith-distance and right-ascension and having shown how to connect the formulæ with the meteorology, we next apply (1) and (2) to the twenty-two observational stretches selected for this tentative investigation, and derive the results shown in Table D. In this table are exhibited the Albany Mean Time; number of observations, original diurnal term, original diurnal term corrected for the various corrections treated of in this paper,

TABLE D

Albany Riefler No. 218

A. M. T.	Obs.	Zenith Distance Orig. Diur.	Corrd. Diur.	C – O	Transits Orig. Diur.	Corrd. Diur.	C – O
h m		″	″	″	″	″	″
23 14 D	3	+0.09	+0.35	+0.26	+0.41	+0.25	–0.16
1 16 D	6	–0.54	–0.22	–0.32	+0.15	+0.02	–0.13
2 8 D	10	+0.08	+0.07	–0.01	+0.32	+0.03	–0.29
3 3 D	26	+0.31	+0.06	–0.25	–0.11	–0.21	+0.10
4 3 D	93	–0.08	–0.11	+0.03	+0.26	+0.18	–0.08
5 0 D	55	+0.01	+0.06	+0.05	+0.38	+0.07	–0.31
5 56 D	30	–0.13	–0.25	+0.12	+0.35	+0.09	–0.26
7 6 D	43	+0.65	+0.09	–0.56	+0.47	+0.05	–0.42
8 4 D	22	+0.65	+0.10	–0.55	+0.71	+0.17	–0.54
8 43 D	1	+1.89	–0.56	–1.33	–0.03	–0.03	0.00
5 18 N	7	+0.18	+0.31	+0.13	+0.11	+0.41	+0.30
6 2 N	35	+0.39	+0.33	–0.06	–0.26	–0.08	–0.18
7 6 N	117	+0.46	+0.23	–0.23	–0.03	–0.06	+0.03
8 2 N	212	+0.50	+0.19	–0.31	–0.57	+0.02	–0.55
8 58 N	245	+0.35	+0.14	–0.21	+0.08	+0.01	–0.07
10 1 N	237	+0.37	+0.16	–0.21	+0.07	+0.07	–0.00
11 0 N	200	+0.32	+0.04	–0.28	+0.13	+0.06	–0.07
11 59 N	120	+0.57	+0.27	–0.30	–0.05	+0.10	+0.05
12 57 N	78	+0.27	+0.16	–0.11	–0.09	–0.08	–0.01
14 1 N	31	+0.19	+0.01	–0.18	+0.27	+0.30	+0.03
15 0 N	37	–0.01	+0.12	+0.08	+0.09	+0.06	–0.03
15 57 N	22	–0.10	+0.03	–0.07	+0.11	–0.01	–0.07
16 46 N	13	+0.25	+0.32	+0.07	+0.12	+0.04	–0.08
18 11 N	23	+0.08	0.00	–0.08	+0.10	+0.05	–0.05
18 32 N	5	–0.28	–0.21	–0.07	+0.51	+0.51	0.00
18 18 D	4	–0.18	–0.11	–0.01	–0.37	–0.22	–0.15
19 2 D	14	+0.22	+0.17	–0.05	+0.05	+0.16	+0.11
20 2 D	16	+0.11	–0.09	–0.05	–0.55	–0.31	–0.24
20 56 D	18	+0.29	+0.33	+0.04	–0.01	+0.07	+0.06
22 1 D	33	–0.10	–0.18	+0.08	–0.10	–0.19	+0.09
22 49 D	19	+0.23	+0.07	–0.16	–0.22	–0.26	+0.01
D PM	289	+0.13	+0.03	–0.10	+0.33	+0.09	–0.24
N	1382	+0.37	+0.10	–0.27	+0.03	+0.04	+0.01
D AM	191	+0.15	+0.07	–0.08	–0.17	–0.08	–0.09
D All	183	+0.11	+0.01	–0.10	+0.13	+0.02	–0.11
N – D		+0.23	+0.06	–0.17	–0.10	+0.02	–0.08

and (C – O). This last is in the sense of reducing the residuals numerically, and not algebraically, which accounts for the preponderance of minus signs. The residuals for transits are in the form $15''n \cos \delta$.

In Table E, the same residuals are used but no distinction is made as to day or night observations. It gives the original diurnal term, diurnal term computed from original by single and double sine and cosine formula, $(O-C)_1$, diurnal term corrected for dR, diurnal term computed from the corrected diurnal term as above, and $(O-C)_2$. In Table D we see that the three groups have been brought nearer together and the *(N – D) has been substantially reduced.*

For zenith distance in E we have

		sin MT	cos MT	sin 2 MT	cos 2 MT	
$Comp_1$ =	$+0''.163$	$+0''.073$	$-0''.168$	$-0''.113$	$-0''.004$	(Original)
$Comp_3$ =	$+0.082$	$+0.087$	-0.109	-0.110	-0.020	($+dR$)
$Comp_2$ =	$+0.082$	-0.014	-0.060	-0.034	$+0.016$	(Residual)

For transits in E we have

$Comp_1$ =	$+0.057$	$+0.074$	$+0.003$	$+0.130$	$+0.007$	(Original)
$Comp_3$ =	$+0.039$	$+0.058$	$+0.057$	$+0.084$	$+0.007$	($+dR$)
$Comp_2$ =	$+0.019$	$+0.016$	-0.053	$+0.046$	$+0.000$	(Residual)

$Comp._3$ is derived from Table E_2 from columns Δn_δ and Δn_z, similarly to $Comp._1$ and $Comp._2$, by single plus double sine and cosine terms, to show that the dR term applied follows the general formula used in discussing the meteorological coefficients. $Comp._1 - Comp._3$ gives $Comp._2$ very closely.

For the investigation of the residual diurnal effect in R. A. and Decl., as shown under corrected diurnal effect in Tables E_3, it must be kept in mind that the Pulkova Tables do not take into account the relative humidity of the atmosphere and also that shade temperatures were used while, as a matter of fact, the daytime observations were not made in the shade but in sunshine. In order to show what effect the use of these terms may have on the diurnal term let us refer to Table C. We have $\mu_\circ$ from shade temperature and μ' from *Sun* temperature, and we can form $\rho' - \rho_\circ$, equals $\Delta\rho_\circ$, by subtracting $\rho_\circ$ of the shade temperature from ρ' of *Sun* temperature. We can also form a ρ'' from the diurnal range of the hygrometer. We have used $\mu_\circ$ in our work on the Albany observations but we wish to use μ'. Let us form μ', $\mu'\Delta\rho_\circ$ and $\mu'\rho''$ as indicated above and solve, using the corrected, or residual, diurnal term of n_z and n_δ as given in Table E_3 for the n's. The form of the equation will then be

$$\mu' + \mu'\Delta\rho_\circ + \mu'\rho'' = n'_z = n'_\delta$$

Solving,

$$\text{Corrd. Diur.} = n'_\delta = +0.041\,\mu' \quad -0.021\,\mu'\Delta\rho' \quad +0.013\,\mu'\rho''$$
$$\text{Corrd. Diur.} = n'_z = +0.041 \quad +0.025 \quad +0.014$$

Substituting these values in the values of residual diurnal terms columns $(O-C)_4$ were obtained. Comparing $(O-C)_4$ of Table E_3 with $(O-C)_2$ of Table E_1 we find that out of 48 residuals, 45 agree in sign; from

TABLE E₁
ZENITH DISTANCES

A. M. T.		Orig. Diur.	Comp.₁	(O–C)₁	Corr'd Diur.	Comp.₂	(O–C)₂
h	m	″	″	″	″	″	″
23	14	+0.09	+0.01	+0.08	+0.35	+0.04	+0.31
1	6	−0.54	−0.06	−0.48	−0.22	+0.02	−0.24
2	8	+0.08	−0.07	+0.15	+0.07	+0.00	+0.07
3	3	+0.31	−0.05	+0.36	+0.06	−0.00	+0.06
4	3	−0.08	+0.02	−0.10	−0.12	+0.00	−0.12
5	2	+0.03	+0.13	−0.10	+0.09	+0.02	+0.07
5	59	+0.15	+0.24	−0.09	−0.06	+0.05	−0.11
7	6	+0.51	+0.36	+0.15	+0.19	+0.09	+0.10
8	2	+0.51	+0.44	+0.07	+0.18	+0.12	+0.06
8	58	+0.36	+0.48	−0.12	+0.13	+0.15	−0.02
10	1	+0.37	+0.47	−0.10	+0.16	+0.16	0.00
11	0	+0.32	+0.41	−0.09	+0.04	+0.17	−0.13
11	59	+0.57	+0.33	+0.24	+0.27	+0.16	+0.11
12	57	+0.27	+0.24	+0.03	+0.16	+0.14	+0.02
14	1	+0.19	+0.15	+0.04	+0.01	+0.12	−0.11
15	0	−0.04	+0.09	−0.13	+0.12	+0.10	+0.02
15	57	−0.10	+0.06	−0.16	+0.03	+0.09	−0.06
16	46	+0.25	+0.06	+0.19	+0.32	+0.08	+0.24
18	12	0.00	+0.10	−0.10	−0.07	+0.05	−0.12
19	0	+0.16	+0.12	+0.04	+0.13	+0.08	+0.05
20	2	+0.14	+0.14	0.00	−0.09	+0.09	−0.18
20	56	+0.29	+0.14	+0.15	+0.33	+0.08	+0.25
22	1	−0.10	+0.10	+0.20	−0.18	+0.07	−0.25
22	49	+0.23	+0.06	−0.17	+0.07	+0.06	+0.01

TABLE E₂

A. M. T.		Zenith Distances $-\Delta n_z$	Comp.₃	(O–C)₃	Transits $-\Delta n_x$	Comp.₃	(O–C)₃
h	m	″	″	″	″	″	″
23	14	−0.26	−0.04	−0.22	+0.16	+0.09	+0.07
1	6	−0.32	−0.08	−0.24	+0.13	+0.16	−0.03
2	8	+0.01	−0.07	+0.08	+0.29	+0.20	+0.09
3	3	+0.25	−0.04	+0.29	+0.10	+0.20	−0.10
4	3	+0.04	+0.02	+0.02	+0.08	+0.19	−0.11
5	2	−0.06	+0.10	−0.16	+0.24	+0.14	+0.10
5	59	+0.21	+0.19	+0.02	+0.02	+0.09	−0.07
7	6	+0.32	+0.27	+0.05	+0.13	+0.03	+0.10
8	2	+0.33	+0.32	+0.01	−0.03	−0.02	−0.01
8	58	+0.23	+0.33	−0.10	−0.09	−0.04	−0.05
10	1	+0.21	+0.30	−0.09	0.00	−0.05	+0.05
11	0	+0.28	+0.25	+0.03	+0.07	−0.04	+0.11
11	59	+0.31	+0.17	+0.13	−0.15	−0.01	−0.14
12	57	+0.11	+0.10	+0.01	−0.01	+0.02	−0.03
14	1	+0.18	+0.03	+0.15	−0.03	+0.04	−0.07
15	0	−0.16	−0.01	−0.15	+0.03	+0.04	−0.01
15	57	−0.13	−0.02	−0.11	+0.15	+0.03	+0.12
16	46	−0.07	−0.02	−0.05	+0.08	+0.01	+0.07
18	12	+0.07	+0.02	+0.05	+0.02	−0.03	+0.05
19	0	+0.03	+0.04	−0.01	−0.10	−0.05	−0.05
20	2	+0.23	+0.06	+0.17	−0.24	−0.06	−0.18
20	56	−0.04	+0.05	−0.09	−0.08	−0.05	−0.03
22	1	+0.08	+0.03	+0.05	+0.09	−0.01	+0.10
22	49	+0.16	−0.00	+0.16	+0.04	+0.03	+0.01

TABLE E₁
TRANSITS

A. M. T.		Orig. Diur.	Comp.₁	(O–C)₁	Corr'd Diur.	Comp.₂	(O–C)₂
h	m	″	″	″	″	″	″
23	14	+0.41	+0.04	+0.37	+0.25	−0.04	+0.21
1	6	+0.15	+0.16	−0.01	+0.02	−0.00	+0.02
2	8	+0.32	+0.22	+0.10	+0.03	+0.02	+0.01
3	3	−0.11	+0.24	−0.35	−0.21	+0.04	−0.25
4	3	+0.27	+0.23	+0.04	+0.19	+0.05	+0.14
5	2	+0.35	+0.19	+0.16	+0.11	+0.04	+0.07
5	59	+0.02	+0.12	−0.10	0.00	+0.04	−0.04
7	6	+0.10	+0.05	+0.05	−0.03	+0.02	−0.05
8	2	+0.01	+0.00	+0.01	+0.04	+0.02	+0.02
8	58	−0.08	−0.02	−0.06	+0.01	+0.02	−0.01
10	1	+0.07	−0.02	+0.09	+0.07	+0.03	+0.04
11	0	+0.13	+0.01	+0.12	+0.06	+0.05	+0.01
11	59	−0.05	+0.06	−0.11	+0.10	+0.07	+0.03
12	57	−0.09	+0.10	−0.19	−0.08	+0.09	−0.17
14	1	+0.27	+0.13	+0.14	+0.30	+0.10	+0.20
15	0	+0.09	+0.13	−0.04	+0.06	+0.09	−0.03
15	57	+0.11	+0.10	+0.01	−0.04	+0.07	−0.11
16	46	+0.12	+0.06	+0.06	+0.04	+0.05	−0.01
18	12	+0.03	−0.04	+0.07	+0.01	−0.00	+0.01
19	0	+0.10	−0.08	+0.18	+0.20	−0.03	+0.23
20	2	−0.55	−0.12	−0.43	−0.31	−0.06	−0.25
20	56	−0.01	−0.12	+0.11	+0.07	−0.08	+0.15
22	1	−0.10	−0.08	−0.02	−0.19	−0.08	−0.11
22	49	−0.22	−0.03	−0.19	−0.26	−0.06	−0.20

TABLE E₃

M.T.	Zenith Distances Corr. Diur.	Comp.₄	(O–C)₄	(O–C)₂	Transits Corr. Diur.	Comp.₄	(O–C)₄	(O–C)₂
h	″	″	″	″	″	″	″	″
23.7	+0.35	−0.04	+0.39	+0.31	+0.25	+0.01	+0.24	+0.21
1.1	− .22	.00	− .22	− .24	+ .02	+ .01	+ .01	+ .02
2.1	+ .07	+ .02	+ .05	+ .07	+ .03	.00	+ .03	+ .01
3.0	+ .06	+ .05	+ .01	+ .06	− .21	+ .01	− .22	− .25
4.0	− .12	+ .07	− .19	− .12	+ .19	+ .02	+ .17	+ .11
5.0	+ .09	+ .08	+ .01	+ .07	+ .11	+ .04	+ .07	+ .07
6.0	− .06	+ .09	− .15	− .11	.00	+ .06	− .06	− .01
7.1	+ .19	+ .11	+ .08	+ .10	− .03	+ .09	− .12	− .05
8.0	+ .18	+ .10	+ .08	+ .06	+ .01	+ .09	− .05	+ .02
9.0	+ .13	+ .08	+ .05	− .02	+ .01	+ .10	− .09	− .01
10.0	+ .16	+ .06	+ .10	.00	+ .07	+ .09	− .02	+ .01
11.0	+ .01	+ .06	− .02	− .13	+ .06	+ .09	− .03	+ .01
12.0	+ .27	+ .06	+ .21	+ .11	+ .10	+ .08	+ .02	+ .03
13.0	+ .16	+ .06	+ .10	+ .02	− .08	+ .08	− .16	− .17
14.0	+ .01	+ .06	− .05	− .11	+ .30	+ .08	+ .22	+ .20
15.0	+ .12	+ .05	+ .07	+ .02	+ .06	+ .08	− .02	− .03
16.0	+ .03	+ .03	.00	− .06	− .01	+ .08	− .12	− .11
16.8	+ .32	+ .02	+ .30	+ .24	+ .04	+ .09	− .05	− .01
18.2	− .07	− .01	− .06	− .12	+ .01	+ .08	− .07	+ .01
19.0	+ .13	− .04	+ .17	+ .05	+ .20	+ .08	+ .12	+ .23
20.0	− .09	− .07	− .02	− .18	− .31	+ .07	− .38	− .25
20.9	+ .33	− .08	+ .41	+ .25	+ .07	+ .06	+ .01	+ .15
22.0	− .18	− .06	− .12	− .25	− .19	+ .05	− .21	− .11
22.8	+ .07	− .05	+ .12	+ .01	− .26	+ .03	− .29	− .20

which we conclude that *if humidity and the Sun temperature had been employed in the original solutions for dR the diurnal term would have been completely eliminated.* And this relation between Comp.$_2$ of Table E_1 and Comp.$_4$ of Table E_3 leads to the most important fact of this entire preliminary investigation — the fact that *the diurnal term is due directly to the atmosphere and that its law is*

$$\text{Diurnal term} = +F\mu\,[a \sin(\alpha - \odot) + b \cos(\alpha - \odot) + c \sin 2(\alpha - \odot) + d \cos 2(\alpha - \odot)]$$
where $\odot$ = apparent R. A. of the *Sun*.

Having thus the law of the diurnal term we can compute the correction for the diurnal term from our observations without knowing the humidity, or the *Sun* temperature. In fact it appears by actual trial that the formula integrates the varying conditions of air in upper and lower levels, and is therefore preferable to the use of a temperature derived solely from the conditions at the *Earth's* surface. But to make it clear to all that we have established this relation, perhaps it will be well to recapitulate and present in a concise form the reasons for this important conclusion.

We will assume that the expressions for dR_1 are accepted. That is,

$$dR_1 = x \quad \sec\delta \quad \sec z\,(1 - .00116 \sec^2 z) \text{ in R. A.}$$
$$dR_1 = x \quad \sec^2 z\,(1.00232 - .003186 \sec^2 z) \text{ in Decl.}$$

We have shown conclusively that the expression

$$a \quad \sin \mathrm{MT} + b \quad \cos \mathrm{MT} + c \quad \sin 2\,\mathrm{MT} + d \quad \cos \mathrm{MT}$$

represents

Natural Phenomena	Observations
Barometer	San Luis Diurnal
Shade Temperature	Albany Diurnal
Sun Temperature	Albany Residual Diurnal
Hygrometer	
Shade Refraction	
Sun Refraction	

Having shown, not only theoretically but practically, that all of these natural phenomena follow one and the self-same law and that when the formulae for dR_1 are combined with the formulae for meteorology and vertical refraction we eliminate the diurnal term in the observations, are we not forced to the conclusion that we have discovered the physical explanation of the diurnal term which has been so troublesome in positional astronomy? With the preceding brief demonstration of the physical relation between the diurnal term and the state of the atmosphere, and the important part that differential refraction has played in enabling us to free our observations of the diurnal effect, it may be of interest to show the effect of dR upon the various systematic errors generally accepted as being inherent in any series of observations.

The following stretches were chosen from a consideration of the effect of dR in R. A. alone. A fair distribution during the year with Clamp East and Clamp West was sought. Due to the fact that the resulting effect was unknown little effort was made to select for a perfect distribution between observers and positions of the instrument. When it was discovered that the dR was a real determinable quantity so far as the R. A.'s were concerned, we decided to examine the Z. D.'s for the same stretches. If the effect was really due to dR, the Z. D.'s would prove it, while, if it was not due to dR, the Z. D.'s would disprove it. The series selected were

Series	Pos.	Obs'r	Time	Date
666–68	*AE*	S.A.	42^h	Aug. 31 to Sept. 1, 1915
669–70	*AE*	S.A.	27	Sept. 2 to Sept. 3, 1915
684–85	*AE*	W.B.V.	30	Sept. 27 to Sept. 28, 1915
686–87	*AE*	W.B.V.	41	Sept. 29 to Sept. 30, 1915
691–94	*AE*	S.A.	67	Oct. 10 to Oct. 13, 1915
700–04	*AW*	Roy	96	Oct. 26 to Oct. 30, 1915
711–14	*AE*	Roy	62	Nov. 15, to Nov. 18, 1915
728–31	*AE*	S.A.	63	Jan. 5 to Jan. 8, 1916
735–37	*AW*	S.A.	33	Jan. 23 to Jan. 25, 1916
739–40	*AW*	W.B.V.	43	Feb. 3 to Feb. 4, 1916
754–57	*AW*	S.A.	86	Mar. 28 to Mar. 31, 1916
760–61	*AE*	Roy	29	Apr. 9 to Apr. 10, 1916
771–74	*AW*	S.A.	65	May 10 to May 13, 1916
784–87	*BE*	S.A.	66	June 26 to July 1, 1916
815–18	*BW*	W.B.V.	80	Aug. 28 to Aug. 31, 1916
825–28	*BW*	W.B.V.	65	Sept. 18 to Sept. 21, 1916
855–57	*BW*	S.A.	41	Dec. 6 to Dec. 8, 1916
866–68	*BE*	Roy	38	Jan. 22 to Jan. 24, 1917
883–85	*BE*	S.A.	51	Mar. 18 to Mar. 20, 1917
903–05	*BE*	S.A.	87	May 13 to May 17, 1917
948–49	*AE*	W.B.V.	40	Nov. 11 to Nov. 12, 1917
950–51	*AE*	W.B.V.	30	Nov. 13 to Nov. 14, 1917

For brevity, we will use the first series in each stretch to designate the stretch. Deriving μ and ρ from Albany meteorology, and solving each stretch according to equations (1) and (2), the following values of coefficients in the formulae for dR were obtained. At the same time these equations were solved, a solution was made for the correction to refraction accord-

ing to former practice; $n = CR$ 100. These values are given under column CR only. These values have been applied to the n's throughout the work on Z. D.'s, giving the opportunity to examine the true effect of using dR as contrasted with CR only, so that in Z. D. we always have three sets of n's; one original n, one $n + CR$, and one $n + dR$. In R. A. we have original n, and $n + dR$.

Stretch	R.A. e	R.A. f	CR only	Z.D C	Z.D e'	Z.D f'
	s	s	″	″	″	″
666	+0.0105	+0.0120	+0.737	+0.484	+0.163	−0.004
669	− .0034	+ .0147	+ .301	+ .115	+ .118	− .081
684	+ .0008	+ .0081	− .111	− .071	− .040	+ .016
686	− .0014	− .0113	− .173	+ .014	− .080	+ .010
691	+ .0096	+ .0212	+ .202	− .311	+ .161	− .046
700	− .0092	− .0014	+ .096	+ .244	+ .057	+ .015
711	+ .0041	+ .0098	−0.026	+ .267	− .079	− .009
728	− .0019	+ .0159	+1.352	+ .972	+ .144	− .008
735	− .0032	+ .0101	+0.402	+ .413	− .002	+ .129
739	+ .0002	+ .0101	− .318	− .219	− .010	+ .192
754	+ .0038	+ .0014	− .214	− .110	− .028	+ .139
760	− .0039	+ .0033	−0.219	− .056	− .158	+ .088
771	+ .0004	+ .0068	−1.251	− .552	+ .217	+ .191
784	+ .0035	+ .0240	−0.469	− .484	− .047	+ .119
815	− .0045	− .0219	+ .404	+ .116	+ .117	+ .014
825	+ .0018	− .0004	− .079	− .058	− .069	+ .219
855	− .0014	− .0002	+ .331	+ .337	+ .026	− .191
866	− .0080	− .0063	+ .120	+ .156	+ .009	+ .110
883	+ .0027	+ .0178	− .437	− .336	+ .096	− .301
903	+ .0103	+ .0117	− .749	− .504	+ .155	− .272
948	+ .0089	− .0277	− .082	+ .011	− .089	+ .361
950	+ .0022	+ .0025	− .258	− .175	− .067	+ .024

Having expanded these values and corrected the original n's we obtained $n + dR = n'$ for Z. D.'s and Transits. Both the original n's and the n's corrected for dR contain the systematic errors $\Delta\alpha_x$, $\Delta\alpha_\delta$, $\Delta\delta_x$, $\Delta\delta_\delta$ and $U-L$, except in so far as the application of dR has elimiated them in the n's. Let us see what the effect of dR has been. Using zones 3° wide, means for $\Delta\delta_\delta$ and $\Delta\alpha_\delta$ were formed. The means of successive groups of three were used to smooth the curve, and these are exhibited in Plate A. The drawing contains sufficient explanation to enable one to understand why they differ but attention should be called to the effect of dR upon the curves, especially the $\Delta\delta_\delta$ curve. The circles represent the results from the n's in order of Z. D. from horizon to horizon. The crosses represent the values derived from below pole observations folded back and transformed to correspond to above pole observations. There can be but one true value of $\Delta\alpha_\delta$ and $\Delta\delta_\delta$ for a given star; any deviation must be due to the observations themselves. While the original observations contain some $(U-L)$, when they are corrected for CR we find this $(U-L)$ is very markedly increased, but when corrected for dR *the* $(U-L)$ *has practically disappeared*, reconciling the observations below and above pole. This alone is an indication that dR is real. The wider deviation from zero of the curve at the south end may be due to systematic error in *P. G. C.* or to the false form of vertical refraction formulae; it is probably due to a combination of both. This point, however, cannot be investigated until the San Luis observations for dR have been examined. Then we hope to be able to indicate the probable source of this wide divergence from zero. Having plotted these points, smooth curves were drawn, and a table formed. That for $\Delta\delta_\delta$ was applied to the Z. D.'s. That for $\Delta\alpha_\delta$ was combined with $(E-W)$. The intimate relation between $(E-W)$ and $\Delta\alpha_\delta$ led to the use of $n' \cos\delta$ in place of n', so

$$[\text{Curve } \Delta\alpha_\delta + (E-W)] \sec\delta = \text{correction.}$$

Correcting Z. D.'s and Transits for these values, thus freeing the observations from the systematic errors $\Delta\alpha_\delta$ and $\Delta\delta_\delta$, we derived n'' from which to obtain $\Delta\alpha_x$ and $\Delta\delta_x$. Hourly means were formed and solved using the clock belt only. This gave

	sin	cos	sin 2	cos 2	
	s	s	s	s	
$n = -\Delta\alpha_x =$	+0.0026	−0.0191	+0.0115	−0.0014	Orig.
$n'' = -\Delta\alpha_x =$	−0.0006	−0.0080	+0.0058	−0.0045	Corrd.
	″	″	″	″	
$n = -\Delta\delta_x =$	−0.104	−0.070	+0.117	−0.049	Orig.
$n'' = -\Delta\delta_x =$	−0.016	−0.012	+0.006	−0.010	Corrd.

The values derived from n'' show the effect of application of dR to original n. *The systematic errors $\Delta\alpha_x$ and $\Delta\delta_x$ have been practically eliminated.* It must be noted here that we have used the value of dR based upon a value of ρ computed from imperfect meteorology. If we compute ρ by formula, as indicated earlier in this paper, we obtain complete elimination of the two systematic errors depending upon right-ascension. These values from computed n'' were expanded and applied to observed n'' giving n''' free from all systematic errors. The n's and n''''s were collected in order of Albany Mean Time giving the diurnal term in Table D treated earlier in this paper. Comparisons of the effect of dR with that of CR on the Z. D.'s are given in Tables F and G. These show that *dR brings the observations north and south of the zenith more into agreement, without the application of a constant.* Table F gives results of application of CR and of dR for each series. It is to be noted that the application of dR has reduced the p. e. by only 0″.01 in the mean, which shows that we are correcting for the systematic shift of the stars and not for the accidental error of the observations. Table G shows how erroneous it is to correct our observations for CR only. When CR only is applied, all the residuals north of the zenith are in-

TABLE I. NORTH STARS

Obs.	n	$n+CR$	$n+dR$	(1)	(2)	(3)	(4)
	″	″	″	″	″	″	″
26	− 7.71	−22.58	0.96	11.51	0.53	23.51	−12.01
20	− 8.15	−12.68	1.78	1.67	1.25	−10.90	2.92
39	5.37	1.21	1.76	− 1.19	0.69	+ 2.18	0.50
37	9.84	9.84	− 1.31	− 1.38	−5.83	11.15	1.45
36	−18.29	−24.09	− 2.95	1.52	3.01	18.44	1.56
69	+11.87	− 8.51	6.49	0.50	0.80	11.70	+ 1.30
69	−27.74	28.46	10.58	+ 0.22	2.31	17.88	2.53
32	+ 3.16	−25.05	− 7.95	−11.29	0.47	17.10	10.82
16	− 8.37	− 4.45	− 3.84	− 1.60	2.23	0.61	0.63
30	− 1.00	− 8.33	0.61	+ 1.13	1.67	8.94	− 3.10
75	+12.25	−21.15	+ 1.13	+ 1.15	+3.18	17.02	+ 2.03
33	−10.92	15.03	0.96	− 1.51	0.26	15.07	1.77
10	+16.88	+11.69	+ 2.03	+11.54	1.31	−39.66	−15.85
17	1.23	− 9.51	+10.26	0.38	+0.98	− 0.75	+ 0.60
67	+12.79	−56.72	+ 8.98	+13.05	9.11	17.71	22.16
54	− 0.16	1.80	− 2.11	0.60	+5.63	0.61	+ 5.63
20	− 3.49	+ 0.56	+ 0.27	1.19	−1.60	0.29	− 0.11
22	− 4.28	− 2.19	+ 1.18	0.25	1.18	1.01	− 0.93
13	+ 2.00	+13.77	− 2.85	+ 2.17	−0.76	10.92	2.93
22	+ 2.85	+11.20	+ 1.99	+ 3.01	0.68	9.21	− 3.69
30	2.10	3.99	1.16	0.29	+1.26	+ 2.73	+ 1.55
35	− 1.24	− 8.56	− 0.22	− 0.16	+1.16	+ 8.31	+ 0.70
862	+71.51	+187.86	+24.67	+62.65	5.93	−163.19	−68.58
Means	+ 0.08	+ 0.22	+ 0.03	+ 0.07	−0.01	− 0.19	− 0.08

TABLE I. SOUTH STARS

Obs.	n	$n+CR$	$n+dR$	(1)	(2)	(3)	(4)
	″	″	″	″	″	″	″
58	+ 18.11	+21.95	+ 0.79	10.58	− 4.00	−21.16	+6.58
10	+ 21.60	+17.06	+ 9.47	− 2.70	− 1.91	− 7.59	+0.79
83	+ 3.22	+ 1.64	+10.57	− 1.92	− 0.23	+ 8.93	+1.69
90	− 19.82	−20.69	+ 7.82	− 2.87	− 5.56	+28.19	−2.69
86	+ 35.95	+25.39	+14.87	− 2.21	+ 0.68	−10.52	+2.89
121	+ 10.15	+17.73	+ 7.15	+ 1.02	+ 0.90	−10.28	−0.12
131	18.22	−15.39	− 1.10	− 0.30	− 0.39	+11.29	−0.09
71	+ 99.76	+31.15	+17.72	−15.01	−38.68	−16.73	+6.36
51	1.35	+ 9.16	+ 9.56	+ 0.09	+ 0.15	+ 0.10	+0.06
74	+ 32.32	+18.50	+12.89	− 6.28	− 8.19	− 5.61	−1.91
108	+ 31.32	+13.66	− 1.19	− 3.18	+ 4.87	−14.85	+8.05
57	− 22.34	−13.08	+11.62	− 5.00	+ 0.94	+21.70	+5.91
121	+115.83	+36.33	− 1.13	−17.10	−10.91	−37.46	+6.16
155	+ 13.76	− 2.87	− 2.52	− 6.97	− 4.73	+ 0.35	+2.24
154	+ 99.39	+61.09	+18.53	−15.87	−12.44	−42.56	+3.13
127	9.71	− 2.33	− 3.41	− 0.47	− 7.03	− 1.08	−6.56
71	+ 20.22	+ 8.98	+ 8.18	− 0.72	− 1.62	− 0.80	−0.90
74	+ 4.16	+ 9.35	+ 7.32	− 0.54	+ 1.17	+ 2.03	+1.71
80	+ 41.85	+20.59	+10.88	− 2.21	+ 2.19	− 9.71	+4.73
46	+ 40.21	+10.03	+ 4.05	−17.46	−16.16	− 5.98	+1.30
73	+ 5.68	+ 9.15	+ 7.58	− 0.05	− 1.21	− 1.57	−1.15
66	− 20.47	−10.15	+ 0.78	− 4.92	− 5.53	+10.93	−0.61
1940	+561.6	+250.8	+150.7	−178.3	−137.4	−100.1	+40.9
Means	+ .29	+ .13	+ .08	− .09	− .07	− .05	+ .02

creased while all the residuals south of the zenith, except the 78 group, are decreased. This is shown in column (4). When, however, we correct n for dR we find the n's are decreased except for the low Z. D.'s each side of the zenith. The appearance of plus signs at each end of column (2) indicates that the formula for vertical refraction may be wrong. This is entirely consistent as all present tables are founded on observations uncorrected for dR. To be sure, when the observations of circumpolar stars have been empirically corrected for $(C-L)$ they have, to a certain extent, been freed from the mean effect of dR. But the particular effect of dR for each stretch has not been taken into account as it should have been.

Table II, which is self-explanatory, shows the effect of dR upon the positions of some of the 19 Primary Azimuth Stars as deduced from the double transits on the stretches employed in this investigation.

Columns (2) and (3) give corrections to places of the 19 Primary Azimuth Stars derived from Albany observations. These corrections are derived from the double transits of the stretches used, corrected for dR. Columns (4) and (5) are the same corrections uncorrected for dR. Column (6) contains the value of $C-L$ derived from corrected values, while (7) is $C-L$ from uncorrected values. Column (8) shows the amount by which $C-L$ in (7) is reduced by dR as given in (6). This is computed in the sense of numerical reduction of $C-L$ and not algebraical reduction, so it indicates the reduction of the probable error of transits of the 19 Azimuth Stars by application of dR, and points to the principal source of $(C-L)$.

TABLE II

No. P.G.C.	(2) C	(3) L	(4) C	(5) L	(6) C−L	(7) C−L	(8)
	s	s	s	s	s	s	s
325	+.098	+.050	+.145	+.175	+.030	−.107	−.597
1801	−.089	+.051	+.025	+.026	−.003	+.150	−.231
1871	−.003	+.009	+.028	+.032	−.013	−.001	−.074
2135	−.194	−.310	−.436	−.253	+.117	−.181	−.036
2536	−.051	−.024	−.050	+.012	−.002	−.013	−.024
4327	+.008	+.009	+.019	−.015	−.029	+.014	+.015
1594	+.125	+.093	+.154	+.038	+.026	+.060	−.112
1974	−1.065	−1.129	−.336	−.940	+.064	+.571	−.510
5199	−.158	−.035	−.178	+.242	−.122	−.120	−.298
218	+.135	+.135	+.270	+.364	.000	−.094	−.091

The effect of dR upon equator point is equally pronounced. This can be well shown by a comparison of the mean equator point derived from the double tran-

PLATE A

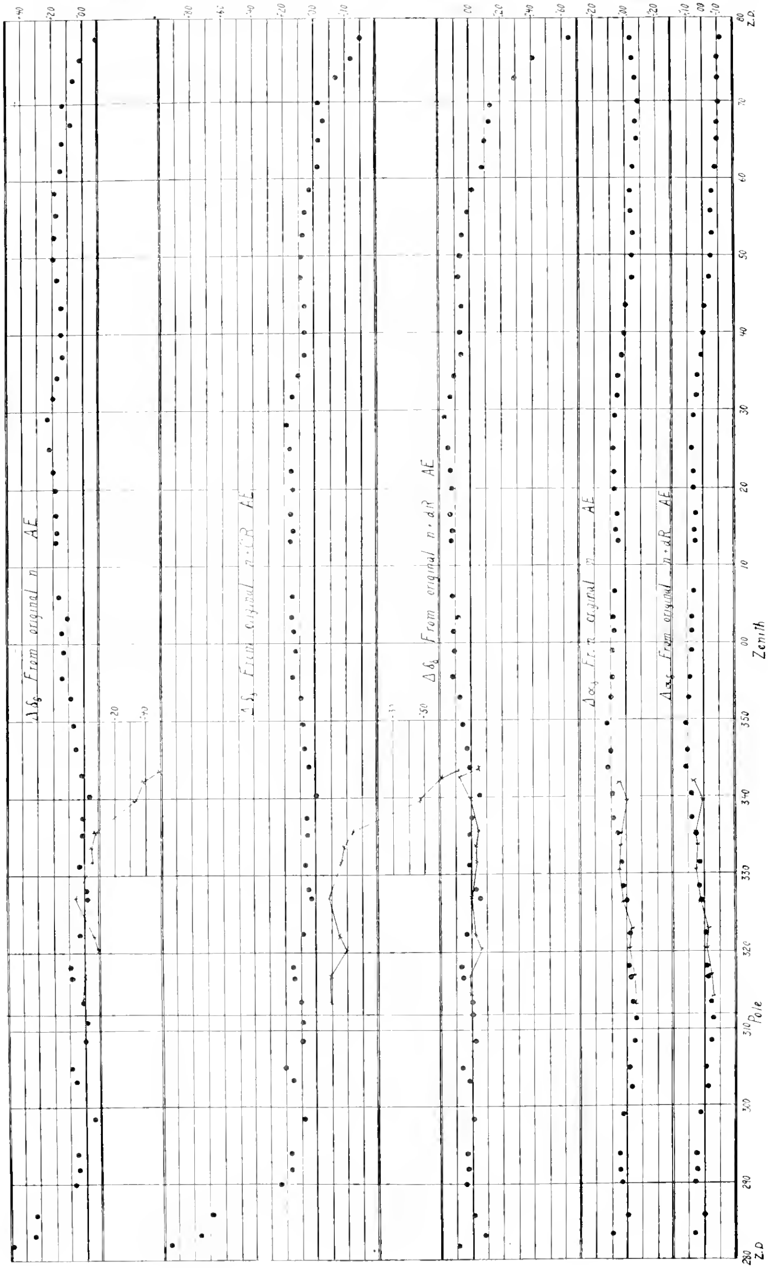


PLATE B

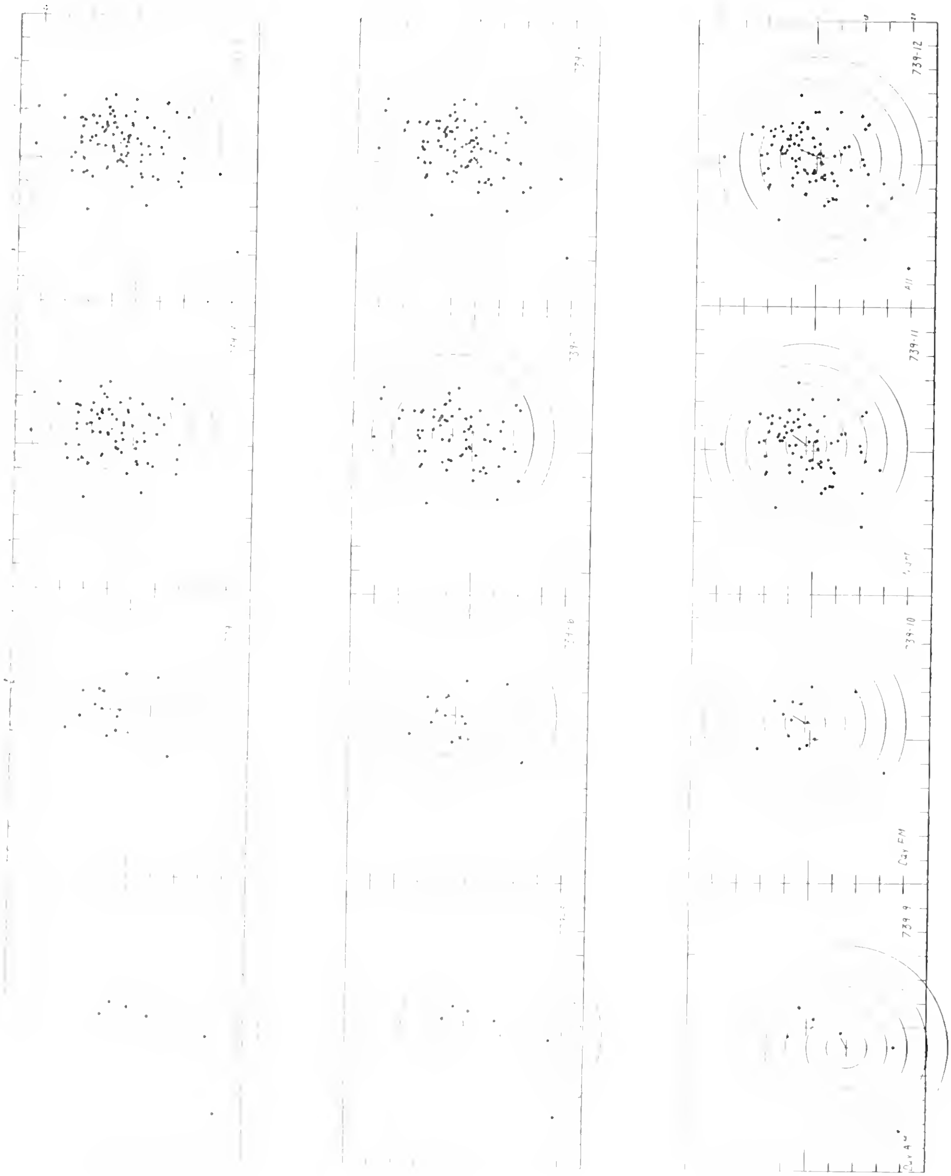
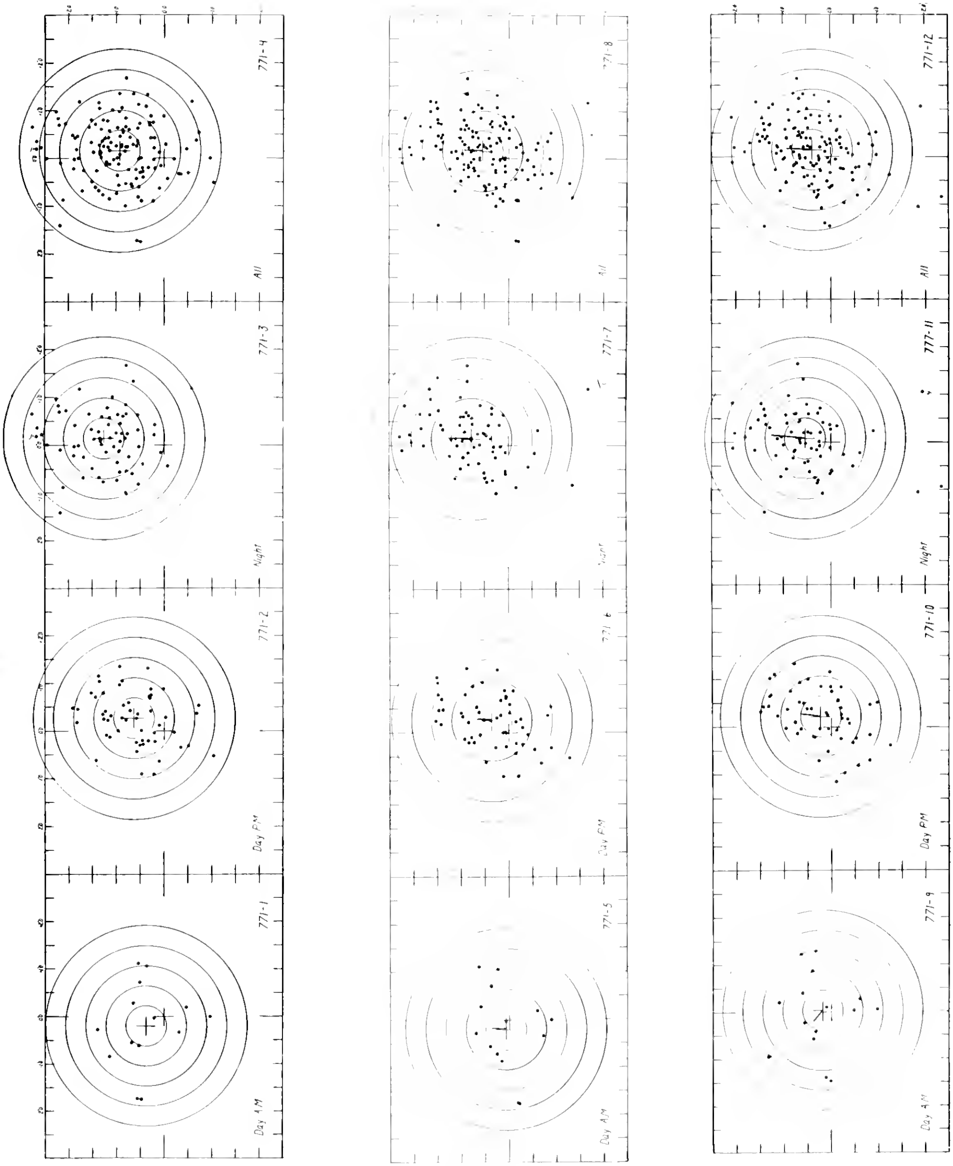


PLATE C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771-3
Night
771-2
Day PM
771-1
Day AM
771-8
771-7
771-6
Day PM
771-5
Day AM
771-12
All
777-11
Night
771-10
Day PM
771-9
Day AM

PLATE D

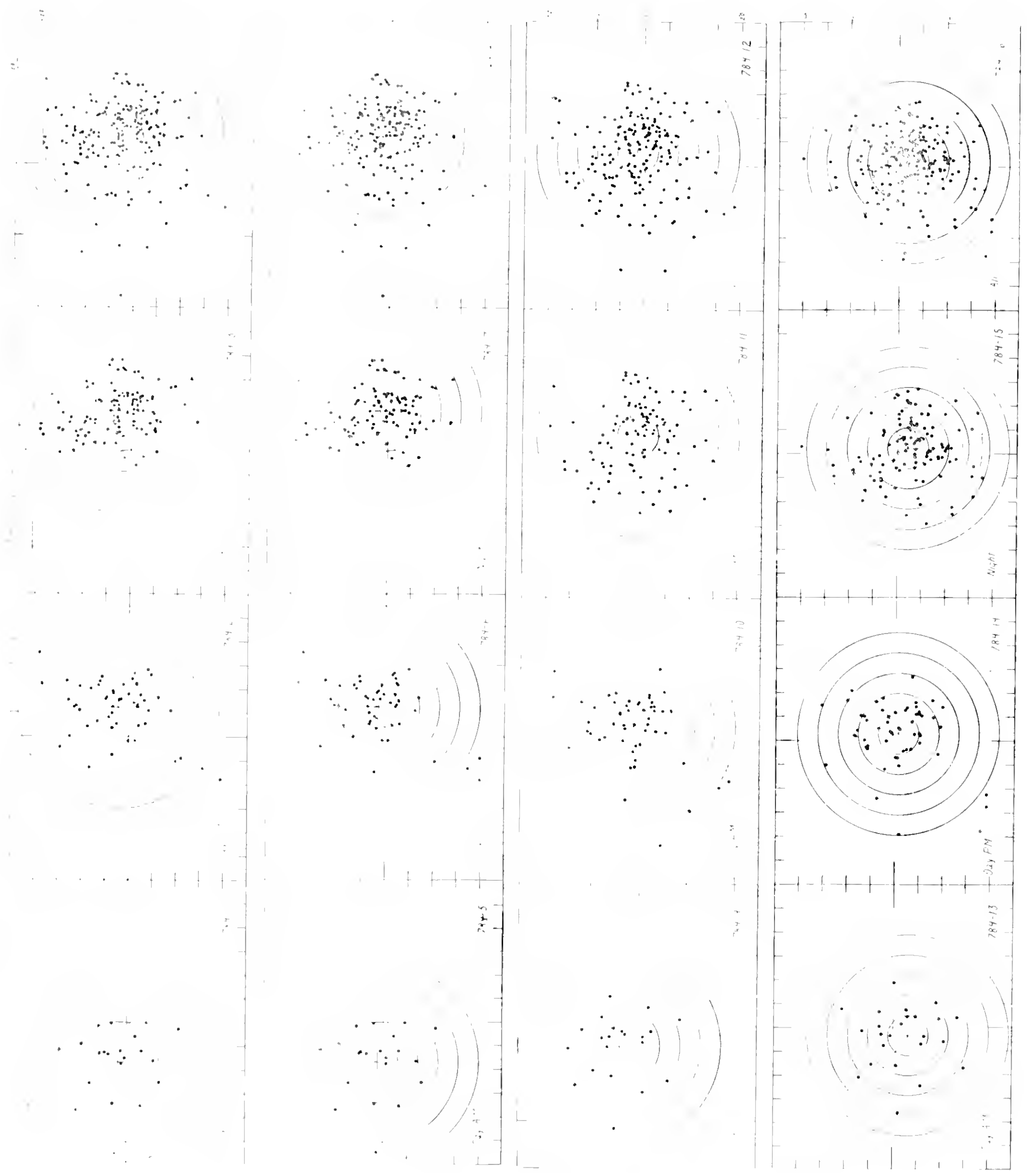


PLATE E

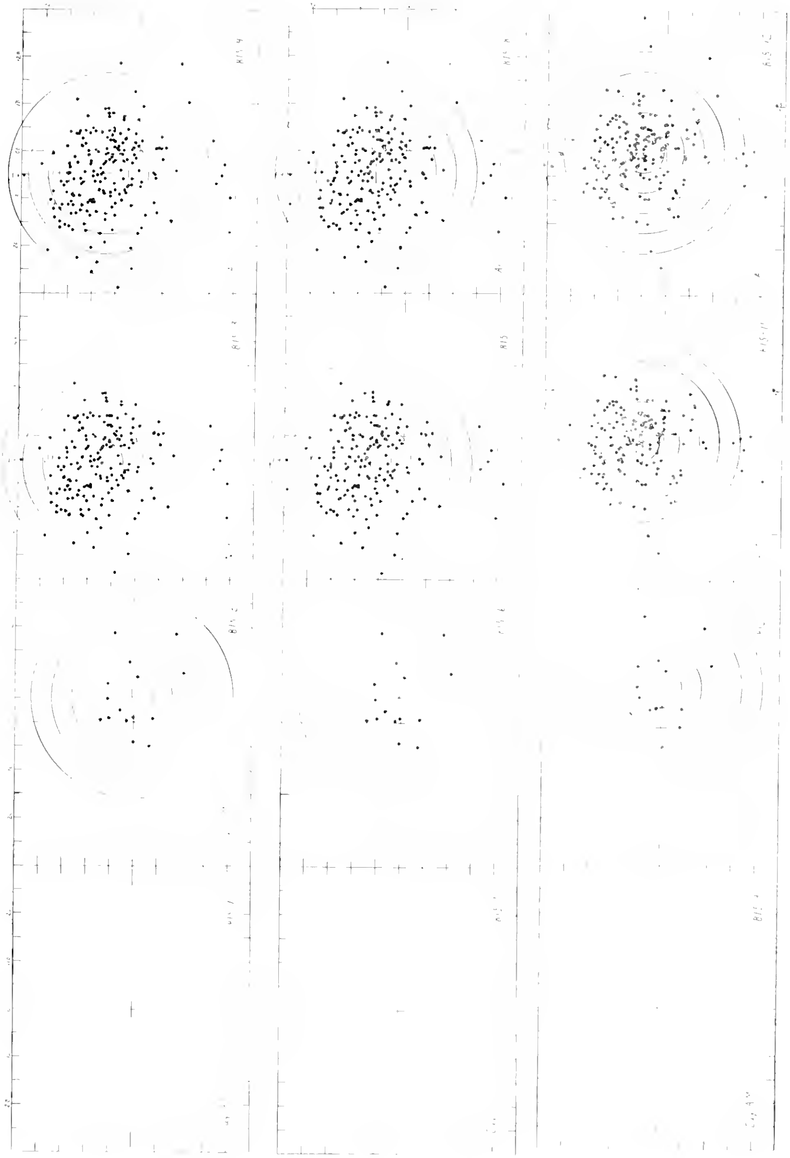
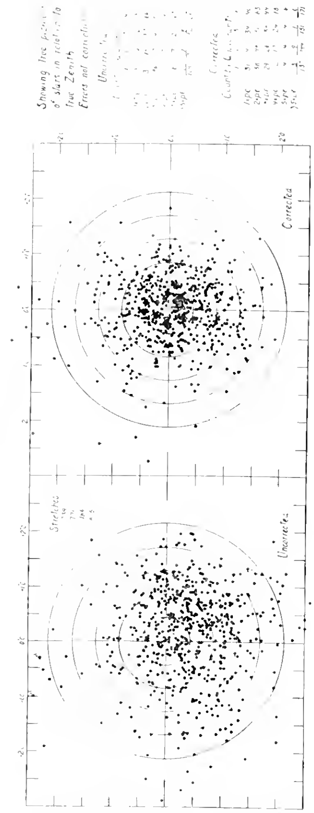


PLATE H



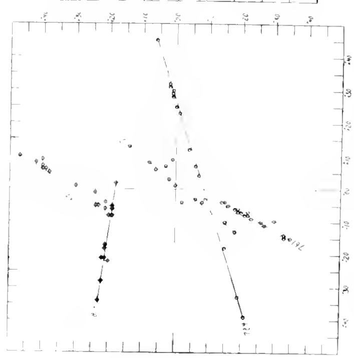
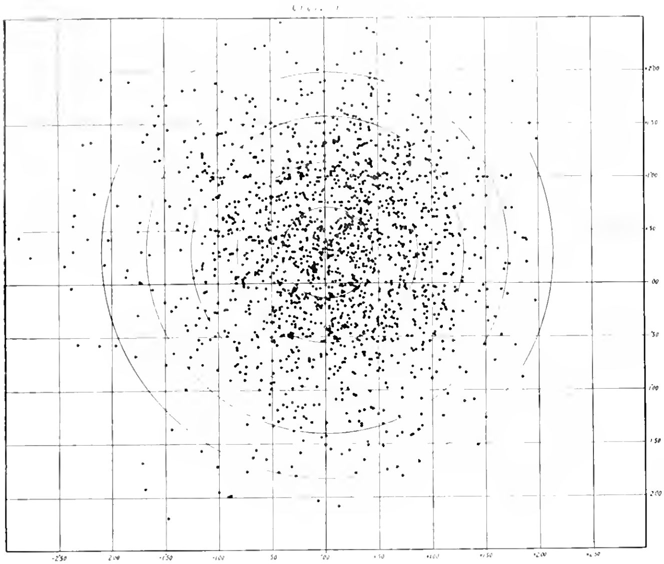


PLATE G

PLATE F



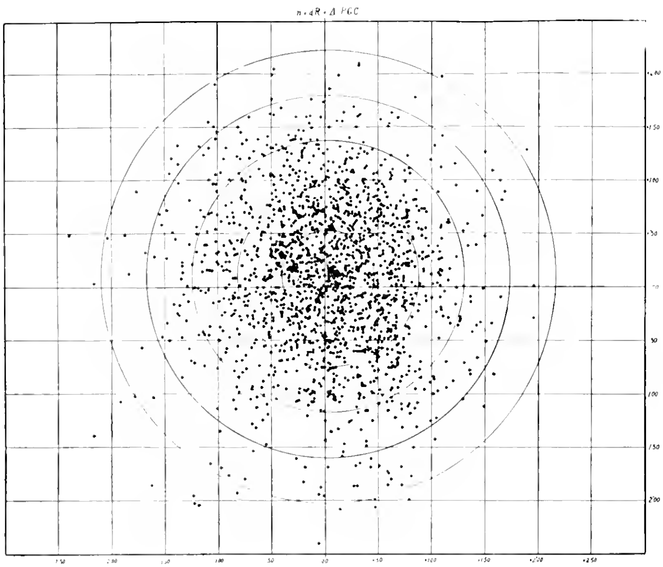


TABLE F NORTH and SOUTH STARS

Obs.	n	$n+CR$	$n+dR$	(1)	(2)	(3)	(4)
	″	″	″	″	″	″	″
81	+ 55.82	+ 44.53	− 0.17	+ 0.93	− 4.53	− 11.70	− 5.46
60	+ 32.75	+ 29.71	+ 11.25	− 1.03	+ 3.16	− 18.19	− 2.13
122	− 2.15	− 2.60	+ 8.81	− 3.73	+ 0.16	+ 11.11	+ 4.19
127	− 29.66	− 30.53	+ 9.13	− 1.19	+ 0.27	+ 39.66	+ 1.76
122	+ 54.24	+ 46.48	+ 17.82	− 0.69	− 2.36	− 28.66	− 1.67
190	+ 22.02	+ 26.24	+ 1.26	+ 0.52	+ 1.70	− 21.98	+ 1.18
200	− 45.96	− 43.85	− 11.68	− 0.08	− 2.70	+ 32.17	− 2.62
106	+ 103.22	+ 59.50	+ 25.67	− 33.75	− 38.21	− 33.83	− 1.16
67	+ 4.02	+ 13.91	+ 13.40	− 1.51	− 2.08	− 0.51	− 0.57
104	+ 33.32	+ 26.83	+ 12.28	− 4.85	− 9.86	− 14.55	− 5.01
183	+ 43.57	+ 34.81	+ 2.94	− 2.03	+ 8.05	− 31.87	+ 10.08
90	− 33.26	− 28.11	+ 10.66	− 3.49	+ 0.68	+ 38.77	+ 4.17
161	+ 132.71	+ 78.02	+ 0.90	− 32.56	− 12.25	− 77.12	− 9.69
202	+ 39.53	+ 6.64	+ 7.74	− 6.59	− 3.75	+ 1.10	+ 2.84
221	+ 142.18	+ 117.81	+ 27.51	− 2.82	− 21.55	− 90.30	− 18.73
181	− 9.90	− 4.13	− 5.82	− 0.47	− 1.40	− 1.69	− 0.93
91	+ 16.73	+ 9.54	+ 8.45	− 1.91	− 3.22	− 1.09	− 1.31
96	+ 8.41	+ 11.84	+ 8.80	− 0.79	− 0.01	− 3.01	+ 0.78
123	+ 43.85	+ 34.36	+ 13.73	− 0.07	+ 1.73	− 20.63	+ 1.80
68	+ 43.06	+ 21.23	+ 6.01	− 11.45	− 16.84	− 15.19	− 2.39
103	+ 3.28	+ 5.16	+ 6.12	− 0.34	+ 0.05	+ 0.96	+ 0.40
101	− 24.71	− 18.71	+ 0.56	− 4.16	− 1.37	+ 19.27	+ 0.09
2802	+ 633.1	+ 438.7	+ 175.4	− 115.7	− 113.4	− 263.3	− 27.7
Means	+ .23	+ .16	+ .06	− .01	− .06	− .09	− .01

sits alone with that obtained through the comparison with *P. G. C.*

	Eq.	Eq + CR	Eq + dR	Eq + dR + $\Delta P.G.C.$
Double Transits	12.69	12.51	12.67	(12.67)
P. G. C. N. of Zen.	12.59	12.45	12.61	12.64
P. G. C. S. of Zen.	12.39	12.54	12.59	12.60
P. G. C. N. and S.	12.45	12.50	12.61	12.61
	″	″	″	
North-South	+0.20	−0.09	+0.05	
	±0.31	±0.19	±0.07	

That is, the application of dR has brought the observations north and south of the zenith to agree within 0″.05, with a p. e. for a single stretch of ±0″.07. At the same time the mean equator point as derived through *P. G. C.* has been made to agree with that derived from double transits within 0″.06. Thus far we have shown that, even with an imperfect knowledge of the meteorology involved, the application of a correction for differential refraction removes the diurnal term, the systematic errors $\Delta\alpha_z$, $\Delta\delta_z$, $(U-L)$, and $(N-S)$, and materially decreases $\Delta\alpha_\delta$ and $\Delta\delta_\delta$; in other words it has straightened the meridian and improved the equator point.

TABLE G

S.Z.D. (AE)	Obs.	n	$n+CR$	$n+dR$	(1)	(2)	(3)	(4)
°		″	″	″	″	″	″	″
282	29	+1.04	+1.82	+ .07	+.64	+.51	−1.71	−.13
287	21	+ .05	+ .61	− .10	+.22	+.26	− .71	+.03
295	41	+ .21	+ .38	+ .13	+.12	+.02	− .25	−.09
305	125	+ .08	+ .25	+ .03	+.06	−.06	− .22	−.12
315	198	+ .08	+ .23	+ .07	+.08	−.00	− .16	−.08
325	115	− .02	+ .05	− .03	+.03	−.03	− .08	−.06
335	105	− .10	− .03	− .08	+.05	−.06	− .05	−.11
345	113	− .02	+ .03	− .03	+.02	−.03	− .06	−.05
355	115	+ .19	+ .21	+ .17	+.01	−.05	− .04	−.06
5	102	+ .23	+ .21	+ .17	−.02	−.07	− .01	−.05
15	287	+ .36	+ .31	+ .29	−.02	−.05	− .02	−.02
25	290	+ .43	+ .36	+ .33	−.05	−.07	− .02	−.01
35	408	+ .28	+ .17	+ .16	−.08	−.11	− .01	−.02
45	205	+ .29	+ .14	+ .13	−.13	−.14	− .01	−.01
55	296	+ .36	+ .12	+ .06	−.17	−.19	− .06	−.02
65	221	+ .16	− .10	− .18	−.18	−.18	− .09	+.00
73	71	+ .16	− .25	− .41	−.09	+.13	− .19	+.22
78	70	− .27	− .84	−1.20	+.08	+.92	− .35	+.84

(1) gives amount by which CR increases or decreases the original n numerically; plus means p.e. is increased and minus the p.e. is decreased. (2) gives same numerical increase or decrease when dR is applied. (3) gives $dR - CR = dR_1$. (4) gives numerical increase or decrease caused by application of dR. These apply to Table F as well as G. Values given in F are sums while those given in G are means.

To present the foregoing discussion in visual form we cease to consider the transits and zenith-distances as separate observations and independent of each other. The residuals formed from them may be taken as the two rectangular coördinates of the star's displacement by atmospheric effects plus accidental error. We will take for the sine component the n in Z. D., and for the cosine component the n of the transits, and we will consider the zenith of our instrument as the zero point for each coördinate. This will conform to Fig. 1. To show that the prismatic effect is real and measurable, and while systematic for a given stretch is not the same for each stretch, Plates B, C, D, E have been prepared. The separate squares of these four plates are numbered alike. 1-4 gives the position of each star as given by the original n. 5-8 gives the position when corrected for CR only, 9-12 the position when corrected for $CR + dR$. For 784 there is also exhibited the results obtained by using the finally concluded value of ρ:

$$\rho = a \sin(\alpha - \odot) + b \cos(\alpha - \odot) + c \sin 2(\alpha - \odot) + d \cos 2(\alpha - \odot)$$

Plate F contains all the stars for the 22 stretches em-

ployed, *omitting p. e.* On plate G are plotted the ephemerides of the meteorological zenith for five stretches for the times when observing was going on. These values are also given in tabular form in Table I. These plates should satisfy the most skeptical that dR is a positive measurable phenomenon.

The diagrams also give the opportunity to study the probable error. In the formation of *P. G. C.* Dr. Boss established as his unit for weight 1.0 the value $\pm 0''.30$ in either coördinate. Hence, if we are allowed $\pm 0''.30$ in R. A. and $\pm 0''.30$ in Z. D. it follows that if we draw a circle whose radius is $\pm 0''.30 \times 1.414$ we include the maximum deviation from the true zenith that is allowable for weight 1.0. That is, the radius of the limiting circle for unit p. e. is $\pm 0''.424$. The circles drawn represent 1.5 times the p. e. for weight 1.0. It certainly is evident that we err if we fail to take into consideration the time of day that the observation was made when discussing such a series of observations as the Albany observations. In 781 to throw out all the observations in R. A. that give n larger than $-1''.50$ among the morning observations would be unjustified, just as to throw away all the daytime observations and confine the reductions to the night observations alone is unjustified, for the night observations are nearly as far from the true meridian, only on the other side. Each set of observations, whether made morning, afternoon, or night is perfectly consistent with the zenith point derived for that time of day. Here we find perfect accordance with, and most striking confirmation of what is pictured in Fig. 1. Studying these plates in connection with Plate G we can see the combined effect of drift and diurnal term. In 771 we have an effect more or less at right angles to that of 781. Here the effect is principally in Z. D. Then in 815 we have an effect that is between the two in Z. D. but opposite in direction to 781 in R. A.

If dR is such an important term in the reduction of the Albany observations it must be the source of the major part of the before and after sunset and sunrise effect as found at other observatories. Tucker found the diurnal effect very marked at Lick Observatory. The dR term is undoubtedly the source of his trouble as given in L. O. Bulletins Nos. 292, 308 and 330. To show this his sunset-sunrise as given in No. 330 was arranged according to Mt. Hamilton Mean Time and ρ was formed from San Francisco Meteorology for 1901-2 as given in U. S. Weather Bureau Reports. (See Table J). Mean values have been used for the months in which the observations were made. These values of ρ are given together with values of sunset-sunrise. Solving for ρ we obtain $O = +0^s.1878\ \rho$ which gives column C when expanded and O–C when

TABLE I. MET. ZEN. EPHEMERIDES

M. T.	739 Z.D.	739 R.A.	761 Z.D.	761 R.A.	771 Z.D.	771 R.A.	781 Z.D.	781 R.A.	815 Z.D.	815 R.A.
h	"	"	"	"	"	"	"	"	"	"
0.5	.	.	–.26	–.10	.	.	.	...	...	...
1.5	.	.	–.23	–.09	+.24	–.01	.	...	+.19	–.05
2.5	.	.	.20	–.07	+.21	–.04	–.06	+.07	+.18	+.02
3.5	+.03	+.07	–.21	–.08	+.30	+.01	–.09	–.03	+.19	–.08
4.5	+.11	+.13	–.18	–.06	+.40	+.07	–.04	+.12	+.20	–.22
5.5	+.08	+.08	–.19	–.06	+.40	+.09	–.01	+.23	.	...
6.5	+.06	+.06	–.16	–.05	+.42	+.08	+.01	+.28	+.22	–.31
7.5	+.08	+.08	–.19	–.07	+.47	+.10	+.02	+.31	+.23	–.31
8.5	+.02	+.03	–.16	–.05	+.42	+.08	+.01	+.30	+.22	–.28
9.5	.00	+.01	–.14	–.04	+.39	+.06	+.01	+.29	+.21	–.21
10.5	+.01	+.09	–.15	–.01	+.38	+.05	.00	+.25	+.21	–.18
11.5	–.02	–.04	–.22	–.08	+.40	+.06	+.01	+.28	+.21	–.17
12.5	.		–.20	–.07	+.30	+.01	+.02	+.32	+.21	–.17
13.5	.	.	.		...	.	+.06	+.45	+.21	–.17
14.5	.		.	.	...	.	.	...	+.20	–.08
15.5	.		.	.	...	.	.	...	+.19	–.06
16.5	.	.	.	.	...	..	.	...	.	.
17.5	.	.	–.22	–.07	...	.	..	...	.	.
18.5	.	.	–.27	–.07	...	.	–.07	+.01	.	.
19.5	.	.	–.33	–.11	.	.	–.21	–.39	.	.
20.5	–.06	–.03	–.33	–.11	+.21	–.05	–.19	–.33	.	.
21.5	–.08	–.01	–.33	–.15	+.23	–.05	–.15	–.18	.	.
22.5	–.15	–.10	–.35	–.15	+.21	–.06	–.	.	.	.
23.5	–.18	–.13	–.30	–.13	.	.	.	...	.	.

applied. It is to be noted that O and C agree as to sign for 47 out of the 58 values. In column O–C, we have 9 minus and 20 plus residuals in place of 29 plus, and 11 plus and 18 minus residuals in place of 29 minus. And if we treat columns O and O–C as residuals for p. e. the ρ-term has reduced the p. e. from $\pm 0^s.030$ to $\pm 0^s.023$. If these observations could have been treated in the same manner in which 781 of the Albany observations was treated there is little doubt that the diurnal term in these residuals could have been almost completely eliminated. This rough test of the Mt. Hamilton results is interesting as evidence that the phenomenon is not purely local.

In Tables K are exhibited groups derived from the residuals as given in Second Series of Washington Observations, Vol. IX, Part 1, pages A73–381. These being the only series of observations conveniently available for testing the theory of dR the residuals as published have been examined in detail. From meteorology furnished by the U. S. Weather Bureau, μ and $\mu\rho$ were formed for each residual and μ, $\mu\rho$ and n were arranged according to Washington Mean Time. These means are exhibited in Tables K, for each group separately and for the two groups combined. In the solution for $F\mu + F\mu\rho$ each observation was assigned weight 1.0. Having in a previous test discovered the importance of the ρ-term and not wishing, at the

TABLE J

Lick — Before and After Sunset and Sunrise

M. T.	ρ	n O	n C	O − C	M. T.	ρ	n O	n C	O − C
h		s	s	s	h		s	s	s
2.7	−.138	+.051	−.026	+.077	12.6	−.052	−.003	−.010	+.007
3.2	−.048	+.051	−9	+60	14.9	−.030	+.008	−6	+14
3.7	+0.28	+.024	+5	+19	15.2	−.077	−.062	−11	−48
3.9	+.104	+.035	+20	+15	15.5	−.134	+.004	−25	+29
4.2	+.050	+.013	+9	+4	15.6	−.077	−.061	−14	−17
4.3	+.071	+.101	+14	+87	15.9	−.146	−.026	−27	+1
4.3	+.094	+.012	+18	−6	16.0	−.139	−.011	−26	+15
4.7	+.070	+.075	+14	+61	16.3	−.238	−.070	−43	−27
4.7	+.014	+.049	+3	+46	16.5	−.221	−.017	−42	+25
4.9	+.048	+.047	+9	+38	16.5	−.254	−.032	−48	+16
5.3	+.108	+.031	+20	+11	16.8	−.143	−.055	−27	−28
5.4	+.081	+0.59	+16	+43	16.9	−.098	−.020	−18	−2
5.4	+.113	+.069	+21	+48	17.0	−.099	−.040	−19	−21
5.8	+.125	+.053	+24	+29	17.3	+.012	−.023	+8	−31
5.9	−.002	+.037	0	+37	17.4	+.139	−.052	+26	−78
6.0	+.091	+.028	+17	+11	17.6	−.036	−.036	−7	−29
6.1	+.204	+.077	+38	+39	17.7	+.066	−.029	+12	−41
6.3	+.190	+.019	+36	+13	17.8	+.018	−.050	+9	−59
6.3	−.110	+.023	−21	+44	18.0	+.006	−.020	+1	−21
6.4	+.063	+.001	+12	−11	18.2	−.136	−.058	−26	−32
6.5	+.196	+.027	+37	−10	18.2	+.036	−.006	+7	−13
6.8	+.183	+.021	+34	−13	18.4	−.098	−.029	−18	−11
6.9	+.084	+.001	+16	−15	18.7	−.302	−.067	−57	−10
7.0	+.266	+.019	+50	−31	18.7	−.026	−.026	−5	−21
7.3	+.112	+.009	+21	−12	18.9	−.241	−.024	−16	+22
7.6	+.310	+.019	+58	−9	19.3	−.122	−.020	−23	+3
8.0	+.206	+.009	+39	−30	19.4	−.394	−.067	−74	+7
8.4	+.092	+.043	+17	+26	19.7	−.174	−.047	−33	−14
8.9	+.036	+.006	+2	+4	20.0	−.204	−.008	−38	+30

present state of the work, to revise including that term, a solution was made for a sin MT + cos MT term as this form of expression has been shown to well represent the ρ. For the dR term we obtained for the 5h group

$$+0^{s}.0036\ F\mu \quad +0^{s}.0056\ F\mu\rho$$
$$+0''.373\ F\mu \quad +0''.051\ F\mu\rho$$

For the 18h group

$$+0^{s}.0119\ F\mu \quad +0^{s}.0034\ F\mu\rho$$
$$+0''.218\ F\mu \quad +0''.101\ F\mu\rho$$

For 5h and 18h groups combined

$$+0^{s}.0077\ F\mu \quad +0^{s}.0057\ F\mu\rho$$
$$+0''.294\ F\mu \quad +0''.059\ F\mu\rho$$

These were expanded for each group as exhibited in the column headed dR. Subtracting these from Mean n_x and n_δ, the column (O−C)$_1$ was obtained. Each value of (O−C)$_1$ shows a well marked cosine term. Also, it is to be noted that the application of dR has almost

TABLE K R. A. Group at 5h 42m

M. T.	n_x	dR	(O − C)$_1$	ρ	(O − C)$_2$
h	s	s	s	s	s
3.6	−.043	+.010	−.053	−.019	−.034
4.6	−.041	+.012	−.053	−.016	−.037
5.6	−.011	+.014	−.025	−.012	−.013
6.5	+.015	+.016	−.001	−.008	+.007
7.4	+.019	+.013	+.006	−.003	+.009
8.5	+.019	+.013	+.006	+.003	+.003
9.5	+.028	+.013	+.015	+.008	+.007
10.4	+.018	+.011	+.007	+.013	−.006
11.6	+.017	+.011	+.006	+.017	−.011
12.5	+.019	+.010	+.009	+.020	−.011
13.5	+.016	+.011	+.005	+.021	−.016
14.5	+.028	+.011	+.017	+.021	−.004
15.5	+.028	+.011	+.017	+.019	−.002
16.5	+.016	+.011	+.005	+.016	−.011
17.5	+.020	+.010	+.010	+.013	−.003
18.1	−.012	+.007	−.019	+.008	−.027
19.2	+.002	+.005	−.003	+.004	−.007
Means	+.010	+.011	−.003		−.009

TABLE K Decl. Group at 5h 42m

μ	$\mu\rho$	M. T.	n_δ	dR	(O−C)$_1$	ρ	(O−C)$_2$
		h	″	″	″	″	″
0.972	+.032	3.6	+.10	+.60	−.50	−.22	−.28
0.985	+.162	4.6	+.08	+.63	−.55	−.17	−.38
1.000	+.356	5.6	+.40	+.65	−.25	−.11	−.14
1.006	+.183	6.5	+.76	+.66	+.10	−.05	+.15
1.030	+.263	7.4	+.76	+.66	+.10	+.02	+.08
1.040	+.242	8.5	+.84	+.67	+.17	+.09	+.08
1.042	+.220	9.5	+.89	+.66	+.23	+.15	+.08
1.044	+.118	10.4	+.79	+.66	+.13	+.20	−.07
1.051	+.103	11.6	+.76	+.66	+.10	+.21	−.11
1.050	+.026	12.5	+.90	+.65	+.25	+.26	−.01
1.030	+.064	13.5	+.85	+.64	+.21	+.26	−.05
1.024	+.090	14.5	+.71	+.64	+.07	+.25	−.18
1.011	+.103	15.5	+.75	+.64	+.11	+.22	−.11
1.009	+.141	16.5	+.92	+.64	+.28	+.17	+.11
0.992	+.079	17.5	+.61	+.62	−.01	+.12	−.13
0.988	−.115	18.4	+.50	+.56	−.06	+.06	−.12
0.980	−.277	19.2	+.61	+.59	+.02	.00	+.02
			+.68	+.64			−.06

completely eliminated the constants in R. A. and Decl. From the above tables we have

	R. A. Mean n	R. A. Mean dR	R. A. Mean (O−C)$_1$	Decl Mean n	Decl Mean dR	Decl Mean (O−C)$_1$
	s	s	s	″	″	″
5h	+0.010	+0.011	−0.003	+0.68	+0.64	+0.02
18h	+0.033	+0.033	+0.002	+0.46	+0.42	+0.04
All	+0.024	+0.022	+0.002	+0.54	+0.52	−0.01

TABLE K. R. A. Group at $18^h\ 5^m$

M. T.	n_x	dR	$(O-C)_1$	ρ	$(O-C)_2$
h	s	s	s	s	s
2.7	+.010	+.031	−.021	−.015	−.006
3.6	+.009	+.032	−.023	−.014	−.009
4.5	+.003	+.034	.031	−.013	−.018
5.5	+.026	+.035	−.009	−.011	+.002
6.5	+.031	+.036	−.005	−.008	+.003
7.5	+.041	+.034	+.007	−.005	+.012
8.5	+.037	+.034	+.003	−.001	+.004
9.5	+.034	+.033	+.001	+.003	−.002
10.4	+.047	+.033	+.014	+.006	+.008
11.4	+.045	+.032	+.013	+.010	+.003
12.5	+.048	+.032	+.016	+.013	+.003
13.5	+.039	+.032	+.007	+.014	−.007
14.5	+.042	+.034	+.008	+.015	−.007
15.5	+.038	+.033	+.005	+.015	−.010
16.5	+.045	+.034	+.011	+.013	−.002
17.5	+.043	+.034	+.009	+.011	−.002
18.5	+.045	+.033	+.012	+.008	+.004
19.4	+.023	+.032	−.009	+.005	−.014
20.3	+.037	+.031	+.006	+.002	+.004
21.4	+.055	+.032	+.023	−.002	+.025
Means	+.033	+.033	+.002		.000

TABLE K. R. A. Groups $5^h\ 42^m$ and $18^h\ 5^m$

M. T.	n_x	dR	$(O-C)_1$	ρ	$(O-C)_2$
h	s	s	s	s	s
2.7	+.010	+.019	−.009	−.013	+.004
3.6	−.009	+.021	−.030	−.014	−.016
4.5	−.018	+.023	−.041	−.014	−.027
5.6	+.007	+.026	−.019	−.013	−.006
6.5	+.023	+.028	−.005	−.012	+.007
7.5	+.030	+.025	+.005	−.009	+.014
8.5	+.028	+.025	+.003	−.006	+.009
9.5	+.031	+.024	+.007	−.002	+.009
10.4	+.032	+.023	+.009	+.001	+.008
11.5	+.028	+.022	+.006	+.005	+.001
12.5	+.029	+.022	+.007	+.008	−.001
13.5	+.024	+.021	+.003	+.011	−.008
14.5	+.033	+.022	+.011	+.013	−.002
15.5	+.032	+.022	+.010	+.014	−.004
16.5	+.031	+.023	+.008	+.014	−.006
17.5	+.032	+.022	+.010	+.013	−.003
18.5	+.019	+.019	.000	+.012	−.012
19.4	+.016	+.018	−.002	+.009	−.011
20.3	+.037	+.018	+.019	+.006	+.013
21.6	+.055	+.017	+.038	+.004	+.034
Means	+.024	+.022	+.002		.000

TABLE K. Decl. Group at $18^h\ 5^m$

μ	$\mu\rho$	M. T.	n_δ	dR	$(O-C)_1$	ρ	$(O-C)_2$
		h	″	″	″	″	″
0.995	−.049	2.7	−.05	+.37	−.42	−.36	−.06
0.983	+.109	3.6	−.05	+.40	−.45	−.34	−.11
0.978	+.310	4.5	+.11	+.44	−.33	−.25	−.08
0.974	+.522	5.5	+.40	+.47	−.07	−.16	+.09
0.967	+.559	6.5	+.47	+.48	−.01	−.06	+.05
0.965	+.398	7.5	+.47	+.45	+.02	+.04	−.02
0.963	+.370	8.5	+.53	+.44	+.09	+.14	−.05
0.964	+.262	9.5	+.59	+.42	+.17	+.22	−.05
0.962	+.226	10.4	+.65	+.42	+.23	+.29	−.06
0.969	+.161	11.4	+.68	+.40	+.28	+.35	−.07
0.977	+.146	12.5	+.77	+.40	+.37	+.38	−.01
0.988	+.126	13.5	+.81	+.41	+.41	+.39	+.02
0.997	+.154	14.5	+.72	+.41	+.31	+.36	.05
1.004	+.159	15.5	+.59	+.43	+.16	+.32	−.16
1.013	+.134	16.5	+.74	+.43	+.31	+.25	+.06
1.026	+.143	17.5	+.61	+.42	+.19	+.16	+.03
1.035	−.017	18.5	+.48	+.39	+.09	+.06	+.03
1.044	−.144	19.4	+.35	+.38	.03	−.03	.00
1.048	.263	20.3	+.26	+.37	.11	−.12	+.01
1.044	−.376	21.4	−.05	+.38	−.43	.19	−.24
Means			+.46	+.42	+.04		−.04

TABLE K. Decl. Groups $5^h\ 42^m$ and $18^h\ 5^m$

μ	$\mu\rho$	M. T.	n_δ	dR	$(O-C)_1$	ρ	$(O-C)_2$
		h	″	″	″	″	″
0.995	−.069	2.7	−.05	+.50	−.55	−.36	−.19
0.980	+.083	3.6	.00	+.51	−.51	−.30	−.21
0.981	+.239	4.5	+.10	+.52	−.42	−.23	−.19
0.986	+.138	5.6	+.40	+.54	−.14	−.13	−.01
0.987	+.524	6.5	+.62	+.55	+.07	−.04	+.11
0.998	+.334	7.5	+.61	+.54	+.07	+.07	.00
1.002	+.306	8.5	+.68	+.54	+.14	+.18	−.04
1.001	+.244	9.5	+.74	+.53	+.21	+.26	−.05
1.005	+.169	10.4	+.72	+.53	+.19	+.33	−.14
1.024	+.125	11.5	+.73	+.52	+.21	+.38	−.17
1.026	+.066	12.5	+.86	+.52	+.34	+.41	−.07
1.016	+.085	13.5	+.84	+.52	+.32	+.40	−.08
1.015	+.144	14.5	+.71	+.52	+.19	+.37	−.18
1.008	+.127	15.5	+.68	+.52	+.16	+.31	−.15
1.014	+.139	16.5	+.83	+.53	+.30	+.23	+.07
1.009	+.111	17.5	+.61	+.52	+.09	+.14	−.05
1.044	.062	18.5	+.49	+.49	.00	+.04	−.04
1.022	−.188	19.4	+.44	+.50	−.06	−.06	.00
1.018	.263	20.3	+.26	+.54	−.28	−.15	−.13
1.044	−.376	21.4	−.05	+.56	−.61	−.23	−.38
Means			+.51	+.52	−.01		−.10

The small values of mean $(O-C)_1$ show that dR has straightened and shifted the meteorological meridian and zenith to agree with the true meridian and zenith of the instrument, and in doing so has eliminated the resultant drift of the observations toward the northeast. $(O-C)_1$ was then solved for a sin WMT $+ b$ cos WMT to obtain the value of the ρ-term in the residual diurnal effect, as for Albany, giving

5^h group

$$\begin{aligned}\rho &= -0^s.0101 \sin \text{W.M.T.} - 0^s.0181 \cos \text{W.M.T.}\\ &= +0^s.0210 \cos (13^h\, 55^m - \text{W.M.T.})\\ &= -0''.082 \sin \text{W.M.T.} - 0''.253 \cos \text{W.M.T.}\\ &= +0''.265 \cos (13^h\, 12^m - \text{W.M.T.})\end{aligned}$$

18^h group

$$\begin{aligned}\rho &= -0^s.0096 \sin \text{W.M.T.} - 0^s.0141 \cos \text{W.M.T.}\\ &= +0^s.0149 \cos (11^h\, 10^m - \text{W.M.T.})\\ &= -0''.103 \sin \text{W.M.T.} - 0''.373 \cos \text{W.M.T.}\\ &= +0''.387 \cos (13^h\, 2^m - \text{W.M.T.})\end{aligned}$$

All

$$\begin{aligned}\rho &= -0^s.0125 \sin \text{W.M.T.} - 0^s.0070 \text{ W.M.T.}\\ &= +0^s.0112 \cos (16^h\, 3^m - \text{W.M.T.})\\ &= -0''.085 \sin \text{W.M.T.} - 0''.398 \cos \text{W.M.T.}\\ &= +0''.407 \cos (12^h\, 18^m - \text{W.M.T.})\end{aligned}$$

The results of these solutions for $F\mu + F\mu\rho$ and ρ terms show that the normal shift for Washington, due to dR, was

$$+0^s.022 \quad +0^s.0142 \cos (16^h\, 3^m - \text{W.M.T.})$$
$$+0''.52 \quad +0''.407 \cos (12^h\, 18^m - \text{W.M.T.})$$

Objection may be made to removing the constant by means of $F\mu + F\mu\rho$ instead of merely taking out a constant. The taking out of the constant before all known forms of error have been corrected for is not defensible, especially when such a well marked cosine term is contained in the residuals. If the n_δ and n_δ were known for each hour of the 24 hours we could assume the means were true constants, but to do so in the present case would be erroneous. In order to show that the ρ-term (a sin W.M.T. $+ b$ cos W.M.T.) will be very little affected by the removal of a constant, a constant was applied to each group and, solving for a sine and and cosine term, we obtained

5^h group

$+0^s.010 \; -0^s.0075 \sin \text{W.M.T.} - 0^s.0209 \cos \text{W.M.T.}$
$+0^s.010 \; +0^s.0222 \cos (13^h\, 19^m - \text{W.M.T.})$
$+0''.68 \; -0''.076 \sin \text{W.M.T.} - 0''.242 \cos \text{W.M.T.}$
$+0''.68 \; +0''.254 \cos (13^h\, 10^m - \text{W.M.T.})$

18^h group

$+0^s.033 \; -0^s.0078 \sin \text{W.M.T.} - 0^s.0138 \cos \text{W.M.T.}$
$+0^s.033 \; +0^s.0159 \cos (13^h\, 58^m - \text{W.M.T.})$
$+0''.46 \; -0''.093 \sin \text{W.M.T.} - 0''.365 \cos \text{W.M.T.}$
$+0''.46 \; +0''.377 \cos (12^h\, 58^m - \text{W.M.T.})$

All

$+0^s.021 \; -0^s.0102 \sin \text{W.M.T.} - 0^s.0080 \cos \text{W.M.T.}$
$+0^s.024 \; +0^s.0130 \cos (15^h\, 30^m - \text{W.M.T.})$
$+0''.51 \; -0''.068 \sin \text{W.M.T.} - 0''.405 \text{ W.M.T.}$
$+0''.51 \; +0''.411 \cos (12^h\, 38^m - \text{W.M.T.})$

The almost perfect agreement of these values with those obtained by using $F\mu + F\mu\rho$ would indicate that the application of dR would help remove the large term in the Washington observations discussed. Also, it will be noticed that the addition of the terms sin 2 MT + cos 2 MT, which were not used in this investigation would, as for Albany, improve the results. That n_δ is not a constant but a very strong, well marked diurnal term is shown in the following exhibit.

WMT	Cos'MT	n'_δ	WMT	Cos''MT	n''_δ	Cos' − Cos''	$n'_\delta - n''_\delta$
h m			h m				
2 41	+.763	−0.05	14 30	−.793	+0.71	+1.56	−0.76
3 38	+.581	0.00	15 30	−.609	+0.68	+1.19	−0.68
4 32	+.375	+0.10	16 29	−.387	+0.83	+0.76	−0.73
5 33	+.118	+0.40	17 28	−.139	+0.61	−0.02	−0.21
6 28	−.122	+0.62	18 28	+.122	+0.49	−0.24	+0.13
7 27	−.371	+0.61	19 22	+.350	+0.44	−0.72	+0.17
8 30	−.609	+0.68	20 17	+.570	+0.26	−1.17	+0.42
9 28	−.788	+0.74	21 6	+.725	−0.05	−1.51	+0.79

In the table, the dependence of n_δ upon the cosine W.M.T. will be recognized at a glance.

This marked dependence upon the time of day that the observation was made is further shown by the variations in the 1700 observations of *α Lyrae*. (See *Popular Astronomy*, Vol. XXX, No. 3, page 165). It would be extremely interesting to see if the correction to nutation from night observations and from day observations would not be much more accordant if the observations were corrected for the effects of dR. And this confirmation of the diurnal term and dR is especially valuable as the observations were made with the prime vertical transit instrument.

In the same volume appears another article which also shows that a diurnal effect is being noticed in *Sun* observations.

	sec z	Δ_z	Δ_z comp		sec z	Δ_z	Δ_z comp.
Jan.	+2.11	+1.01	+1.01	July	−0.53	−0.89	−0.22
Feb.	+0.95	+1.19	+0.10	Aug.	−0.43	−0.83	−0.18
Mar.	+0.11	+0.18	+0.05	Sept.	−0.14	−0.69	−0.06
Apr.	−0.31	−0.37	−0.14	Oct.	+0.52	+0.25	+0.22
May	−0.52	−0.18	−0.22	Nov.	+1.82	+0.67	+0.76
June	−0.56	−0.52	−0.21	Dec.	+3.00	+1.02	+1.26

Column sec z is derived by subtracting sec z of the Washington latitude from sec z of the *Sun's* declination. Δ_z is copied from HAMMOND's article and Δ_z comp. is derived from a solution giving $\Delta_z = +0''.12$ sec z. The perfect agreement in sign and the general reduction of the original residuals suggests that there may be some connection between dR and Δ_z.

In the *Annuaris Astronomicopel* 1923, TORINO appears an article on the Diurnal Variation of Latitude which would appear to be another manifestation of the effect of dR. After conference with DR. KIMURA on the occasion of his recent visit to the Dudley Observatory, it seems probable that the effect of differential refraction on the latitude observations will remove a large part at least of the z-term. Then there is the question as to what extent the dR term effects the observations of the *Sun*, *Moon*, and *Planets*, both directly and indirectly, through the adopted clock corrections. Also, this phenomenon is undoubtedly the cause of different systematic corrections to catalogues, depending on whether we use bright or faint stars. In the observations of the bright stars, taken more or less throughout the 24 hours of the day, the effect of dR will tend to eliminate; in the observations of the faint stars taken always at night it will not. The various attempts to solve this perplexing problem have held up the reductions of the San Luis and Albany observations for some time and we are fully aware of the impatience felt, in some quarters, over the long delay. Inasmuch, however, as the series of investigations have enabled us to explain in a natural way so many of the points which have been puzzling meridian observers for years, we feel that the time has been well spent. With physical explanations for most of the known systematic errors and means of eliminating or evaluating them, we plan to reduce and discuss all the Fundamental stretches both in R. A. and Z. D., for both series of observations, those of San Luis and Albany, as one connected series, as only by so doing can certain fundamental questions be settled.

In this preliminary investigation *no rejections nor changes in the original data have been allowed.* All corrections, such as corrections to circle readings derived from the Nadir, (N S) both in R. A. and Z. D., and sine flexure, have been considered as absolute. In other words, *all instrumental corrections determined by special observations have been considered as final and so used.* All observations have been used with their full weight. In the second approximation we shall feel warranted in rejecting all residuals exceeding 5 x p. e., after the residuals have been corrected by the first approximation. In this way, we hope to obtain true positions of the stars and not the positions of the stars as they should have been to agree with the other determinations. And, in using the places of *P. G. C.*, we will endeavor to so combine the observations that, except for the zero point in R. A., concluded positions will be independent of *P. G. C.* As indicated elsewhere, *P. G. C.* places will be used only as a rough scale to determine the systematic errors in the observations and then the errors of the scale will be determined.

SUMMARY

1. There is a varying prismatic effect due to the changes in the strata of the atmosphere.

2. The total effect is essentially a shift of the meteorological zenith.

3. The temperature, and not the barometer, is the controlling factor.

4. Expressions have been derived for the effect of this phenomenon on observations.

5. When these expressions have been applied to the observations, the (N D) has been substantially reduced. If humidity and *Sun*-temperature had been employed in the original solution for dR, the diurnal term would have been completely eliminated.

6. The diurnal term is due directly to the atmosphere. Its law is $a \sin (\alpha - \odot) + b \cos (\alpha - \odot) + c \sin 2(\alpha - \odot) + d \cos 2(\alpha - \odot)$.

7. The systematic corrections $\Delta\alpha_z$ and $\Delta\delta_z$ have been practically eliminated.

8. The application of dR brings the observations north and south of the zenith into better agreement without the application of a constant.

9. Tests of published results of other observatories show that the phenomenon is not local.

Footnote: In Part II, to be published as an appendix to the reprint of this article we will give the formula for and discussion of our method of "fundamental reductions," presenting the detailed method of eliminating and evaluating all systematic errors.

Dudley Observatory,
March 28, 1922.

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OBSERVATIONS OF COMET 1921*a* (REID),

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

By ERNEST CLARE BOWER.

[Communicated by Captain W. D. MacDougall, U. S. Navy, Superintendent of U. S. Naval Observatory]

G. M. T.	App. α	App. δ	Δα	Δδ	Comp.	log pΔ		Ap. pl. red. of ★		Seeing	★
1921	h m s	° ′ ″	m s	′ ″				s	″		
Mar. 22.91679	20 19 19.53	−13 47 27.6	−0 11.56	−1 14.3	d10 , 8	9.566n	0.803	+0.55	+6.5	vp	1
26.91826	20 21 33.78	−10 56 33.5	+0 24.51	+1 28.5	d12 , 8	9.536n	0.798	+0.64	+6.0	p	3
28.87715	20 22 39.44	− 9 21 31.9	−0 12.72	+2 22.9	d10 , 8	9.606n	0.776	+0.68	+5.7	vp	5
Apr. 1.88834	20 24 55.89	− 5 37 17.7	−1 28.15	+1 24.8	[illegible]40 , [illegible]	9.566n	0.769	+0.77	+1.[illegible]	p	6
May 9.63938	3 1 38.39	+85 25 21.6	−0 10.29	−0 25.4	d10 , [illegible]	0.383	0.822	−4.25	−1.7	f	7
16.68679	7 25 35.55	+74 5 18.7	−1 1.94	+1 37.2	d10 , 8	0.186	0.612	+0.15	+2.[illegible]	f	9
20.74361	7 44 22.25	+68 14 35.3	−0 51.52	−0 15.3	d10 , 8	0.019	0.734	+0.39	+1.[illegible]	f	10
31.69067	8 2 17.54	+57 13 24.3	+0 1.51	−0 12.9	d10 , 8	9.861	0.769	+0.55	−1.7	p	11

Mar. 26. Faint. Clouds. Twilight. Hurried. Wires fluctuating. Very poor observation. Mar. 28. 10m. Apr. 1. Poor transits of comet. May 16. 7m. May 20. Bright moonlight. Haze.

Mean Places of Comparison Stars for Beginning of Year

★	α	δ	Authority
	h m s	° ′ ″	
1	20 19 33.51	−13 46 49.8	11m. comp. with 2. 1921 Mar. 26, $\Delta\alpha = -9^s.38$, $\Delta\delta = -7' 13''.6$, 1921.0
2	20 19 42.92	−13 39 6.2	½ *A.G.* { *Camb. U.S.* 7195; *Wash'n* 7673 }
3	20 21 8.60	−10 58 8.0	*B.D.* −11.5328 (9.2) comp. with 4. 1921 Apr. 1. $\Delta\alpha = +1^m 44^s.37$ $\Delta\delta = -2' 32''.1$, 1921.0
4	20 19 24.23	−10 55 35.9	*A.G. Camb. U.S.* 7191
5	20 22 51.48	− 9 24 0.5	*A.G. Wien-Ottak.* 7256
6	20 26 23.27	− 5 39 47.3	½ *A.G.* { *Wien-Ottak.* 7286; *Straszburg* 7105 }
7	3 1 52.93	+85 25 48.7	11m. comp. with 8, 1921 Nov. 22. $\Delta\alpha = -5^m 1^s.21$, $\Delta\delta = +3'20''.0$, 1921.0
8	3 6 57.11	+85 22 28.7	*Astr. Gen.* 1900, 734
9	7 26 40.31	+74 3 38.9	½ *Astr. Gen.* { +74.0736, 3031; +75.0715, 3031 }
10	7 45 16.38	+68 14 19.3	*Astr. Gen.* 1900, 12728
11	8 2 12.48	+57 13 38.[illegible]	*B.D.* +57.1122 (9.5) comp. with 12. 1921 Nov. 29. $\Delta\alpha = +7^m 11^s.12$, $\Delta\delta = +3'51''.1$, 1921.0
12	7 55 1.36	+57 9 47.8	*A.G. Hels.* 5321

U. S. Naval Observatory, Washington, D. C.,
1922, Mar. 10.

THE ORBIT OF COMET 1788 II.*

By MARGARETTA PALMER.

Comet 1788 II, the second discovered by CAROLINE HERSCHEL, was first seen by her (*Philosophical Transactions*, volume LXXIX, 1789, page 151; *Memoir and Correspondence of Caroline Herschel*, page 83) December 21, 1788, at her brother's observatory at Slough, where it was also observed by the latter with his 10-foot reflector that evening and several times later.

HERSCHEL describes the comet at the time of discovery (*Memoir and Correspondence*, page 83) as "a pretty visible object," "a much larger object than the nebula near β *Lyræ*, discovered by MR. DARQUIER, of Toulouse (*Connaissance des Temps*, page 75)." Again (*Memoir*, page 84) he says that in his "10-foot reflector it had the appearance of a considerably bright nebula, of an irregular, round form, very gradually brighter in the middle, and about 5 or 6 minutes in diameter," adding, "the siutation was low, and not very proper for instruments with high powers." From this comparison with the nebula the comet with its greater diameter and situation near the horizon might be considered as of magnitude 7.5 or 8. Under date of December 22 HERSCHEL writes, "This and several evenings afterwards I viewed the comet again with such powers as its diluted light would permit, but could not perceive any sort of nucleus which, had it been a single second in diameter, I think, could not well have escaped me."

* Read at the Swarthmore meeting of the American Astronomical Society, December, 1921.

The recorded observations leave no doubt that the comet was at all times an inconspicuous object without any visible tail. As, however, it was not observed till long after perihelion and as it was situated too low for good observations a tail would scarcely have been visible. The comet showed no distinct nucleus. Full details of its physical appearance and theoretical brilliancy are given by HOLETSCHEK (*Grösse und Helligkeit der Kometen* 2, 1905, pages 572–574).

This comet was observed by four observers at four observatories on sixteen nights. It passed its perihelion November 20, and was nearest the earth October 31, when it was about 75,000,000 miles distant from it. During the forty-five days of its visibility it traversed 14° in right ascension and 33° in declination. The heliocentric arc traversed was 36°.

The *Sun's* coördinates, given below, were computed from NEWCOMB'S *Tables of the Sun* for Berlin mean noon of every second day. This table, as well as the corresponding tables for Comet 1786 II (*Astronomical Journal* 744, page 189) and comet 1797, whose definitive orbit is not yet completed, was computed before a definite plan of procedure was decided upon. It was, therefore, less laborious to utilize these tables than to repeat the computations for Greenwich mean noon, which should have been chosen. The checking by means of HANSEN'S *Tables*, as well as other details of the present discussion, was carried out in a manner exactly similar to the former work.

TABLE I

Sun's COÖRDINATES FOR BERLIN MEAN MOON, EQUATOR AND MEAN EQUINOX, 1789.0

Berlin Mean Time	Longitude	Latitude	log. R	X	Y	Z	Sidereal Time of Mean Noon	Equation of Time
1788	° ′ ″	″					h m s	m s
Dec. 18.0	267 19 15.18	−0.65	9.9927915	−0.0159732	−0.9012106	−0.3912389	17 50 52.03	− 2 33.36
20.0	269 21 30.28	.61	9.9927516	− .0110123	.9020544	.3916036	58 15.14	1 33.46
22.0	271 23 18.09	.41	9.9927175	+ .0239691	.9017694	.3914803	18 6 38.25	− 0 33.29
24.0	273 26 8.10	− .19	9.9926910	.0589262	.9003644	.3908678	14 31.37	+ 0 26.89
26.0	275 28 29.63	+ .06	9.9926717	.0938133	.8978287	.3897669	22 21.49	1 26.75
28.0	277 30 51.91	.27	9.9926593	.1285839	.8941719	.3881784	30 17.61	2 25.99
30.0	279 32 14.30	+0.44	9.9926538	+0.1631927	−0.8893970	−0.3861046	18 38 10.73	3 21.25
1789								
Jan. 1.0	281 35 36.12	+0.49	9.9926556	+0.1975946	−0.8835101	−0.3835188	18 46 3.81	4 21.42
3.0	283 37 56.76	.43	9.9926652	.2317451	.8765208	.3805148	53 56.95	5 17.06
5.0	285 40 15.66	.28	9.9926833	.2656008	.8684401	.3770076	19 1 50.05	6 10.98
7.0	287 42 32.52	+ .04	9.9927109	.2991205	.8592806	.3730325	9 43.17	7 2.91
9.0	289 44 47.07	− .23	9.9927488	+ .3322635	− .8490566	− .3685955	17 36.29	+ 7 52.74

Berlin Mean Time	Longitude	Latitude	log. R	X	Y	Z	Sidereal Time of Mean Noon	Equation of Time
1789	° ′ ″	″					h m s	m s
Jan. 11.0	291 46 59.41	−0.47	9.9927979	+0.3649918	−0.8377821	−0.3637023	19 25 29.42	+ 8 10.21
13.0	293 49 9.80	.62	9.9928586	.3972683	.8254723	.3583590	33 22.54	9 25.18
15.0	295 51 18.59	.64	9.9929306	.4290564	.8121406	.3525715	41 15.65	10 7.58
17.0	297 53 25.94	.55	9.9930130	.4603183	.7978016	.3463461	49 8.75	10 47.28
19.0	299 55 31.77	.34	9.9931015	.4910150	.7824701	.3396892	57 1.86	11 24.17
21.0	301 57 35.64	− .09	9.9932039	.5211068	.7661636	.3326090	20 4 54.97	11 58.10
23.0	303 59 37.10	+ .16	9.9933103	.5505546	.7489013	.3251138	12 48.10	12 28.96
25.0	306 1 35.52	.35	9.9934229	.5793195	.7307052	.3172135	20 41.21	12 56.70
27.0	308 3 30.21	.46	9.9935415	.6073614	.7115992	.3089186	28 34.32	13 21.20
29.0	310 5 20.57	.47	9.9936660	.6346534	.6916094	.3002402	36 27.43	13 42.38
31.0	312 7 5.95	.39	9.9937963	.6611517	.6707620	.2911906	44 20.53	14 0.23
Feb. 2.0	314 8 45.77	+ .19	9.9939330	.6868275	.6490871	.2817821	52 13.63	14 14.73
4.0	316 10 19.61	− .05	9.9940766	.7116503	.6266112	.2720273	21 0 6.74	14 25.86
6.0	318 11 47.15	.31	9.9942278	.7355925	.6033737	.2619394	7 59.86	14 33.65
8.0	320 13 8.30	−0.50	9.9943878	+0.7586282	−0.5793969	−0.2515316	15 52.98	+14 38.11

1789.0 $\epsilon = 23° 28' 0''.26$

Of the two systems of elements computed by Méchain (*Mémoires de Paris* 1789, page 684; *Berliner Jahrbuch*, 1793, page 119; and *Connaissance des Temps*, 1792, page 351; *Berliner Jahrbuch*, 1794, page 93) the latter, derived from his own observations with those of Messier and Maskelyne, was assumed as the basis of this discussion. As, however, the observed places were found to differ considerably from this orbit Méchain's elements were examined with a view to a preliminary correction. The extremely doubtful February observations were omitted and, since the later January observations were also uncertain, January 6 was selected as the date of the middle place. Normal places were found for December 26.0, January 5.5, and January 16.0. The angle between the great circles on which the first and third places of the comet and the middle places of the *Earth* and comet, respectively, were situated — Hansen's critical angle — was found to be 1° 6′. The difference $\beta_2 - \beta_0$, $+13'$, showed that the middle place of the comet lay not far from the great circle passing through the first and third places. Moreover, this great circle cut the ecliptic within about 1° of the *Earth's* middle place. A solution by varying the geocentric distances, using these three normal places, would, therefore, be very uncertain. Discarding the earliest observations and forming normal places for January 5.5, 16.0, and 29.0, Hansen's critical angle has the value 11° 27′. The great circle through these first and third places cuts the ecliptic 10° 17′ from the *Earth's* second place. The difference $\beta_2 - \beta_0$ is 1° 16′. As, however, the observations used to form the normal place for January 29.0 were very uncertain and the value of the critical angle was so close to the limit of uncertain determination from three places, the method of varying the geocentric distances promised no satisfactory results. It was decided, therefore, to use Méchain's second system of elements for the least-squares solution, repeating the solution, if advisable.

	Méchain I		Méchain II	
T =	1788, November 20.41527 *B. M. T.*		November 20.33975 *B. M. T.*	
ϖ =	31° 30′ 7″	1789.0	30° 25′ 28″	1789.0
Ω =	351 42 15		352 24 26	
i =	64 52 32		64 30 24	
log q =	9.885988		9.879276	

In the above the time of perihelion passage has been changed from Paris mean time to Berlin mean time and ϖ substituted for π.

Rectangular heliocentric equatorial coordinates (elements MÉCHAIN II)

$$\left.\begin{aligned} x &= [9.876165] \sin (117^\circ\ 8'\ 26''.89 + v) \sec^2 \tfrac{1}{2} v \\ y &= [8.977332] \sin (315\ \ 10\ \ 10\ .81 + v) \sec^2 \tfrac{1}{2} v \\ z &= [9.878953] \sin (\ \ 27\ \ 21\ \ 21\ .84 + v) \sec^2 \tfrac{1}{2} v \end{aligned}\right\} 1789.0$$

The comet 1788 II was observed at Slough, near Windsor, by HERSCHEL (*Astronomical Observations Greenwich*, volume III, *Equatoreal Sector* [an appendix], page 15); at Greenwich, by MASKELYNE (*loc. cit.*); at Paris, l'Observatoire de la Marine, Hôtel de Clugny, by MESSIER (*Mémoires de Paris*, 1789, page 683); and at Paris l'Observatoire Royale, by MÉCHAIN (*loc. cit.* and *Berliner Jahrbuch* 1793, page 149).

Whenever possible, the observations were re-reduced. The times were corrected for aberration (distance unity 498.5 seconds). By means of BAUSCHINGER's *Tafeln* the parallax factors were computed (solar parallax 8".80). For a few of the observations of MASKELYNE and MESSIER refractions were computed. In other cases the effect of refraction was entirely negligible.

The places of the comparison stars for 1789.0 were carefully determined. For stars not found in the *Neue Fundamental Katalog*, in AUWERS'S BRADLEY, or in BOSS'S *Preliminary General Catalogue* the various catalogue positions were reduced, with proper-motions, and combined in the usual manner.

For the observations of HERSCHEL, MASKELYNE, and MESSIER the given differences, comet minus star, were applied to the newly deduced star places. In the case of MÉCHAIN's observations, the apparent right ascensions and declinations of the comet being given with no further details, corrections were applied for parallax only.

The difficulty of always fixing upon the same point for observations in the case of a comet without well-defined nucleus, its situation near the horizon, and the uncertainty due to the faintness of the comet during the latter part of its visibility, made large errors of observation inevitable. A comparison of the observations with positions computed from the elements MÉCHAIN II showed this to be the case. Curves plotted with $\Delta\alpha \cos\delta$ and $\Delta\delta$ as ordinates and the times as abscissas were similar although single observations showed great divergence. The small number of observations by any single observer combined with the general inaccuracy of the observations themselves precluded the possibility of determining weights for the different series.

TABLE II

No.	Berlin Mean Time	Place	$\Delta\alpha \cos\delta$ (O – C)	p_α	$\Delta\delta$ (O – C)	p_δ	$\Delta\alpha \cos\delta$ II (O – C)	$\Delta\delta$ II (O – C)
			s		"		s	"
1	1788 Dec. 22.2732	Slough	−0.09	0.5	+ 42.8	0.5	−1.63	+32.2
2	23.2517	Slough	+2.75	0.5	− 11.6	0.5	+1.42	−56.8
3	26.3055	Greenwich	+2.50	1	+ 16.9	1	+1.81	+ 3.7
4	28.2598	Greenwich	−0.41	1	+ 37.0	1	−0.67	+24.2
5	1789 Jan. 2.2925	Greenwich	+3.74	0.5	+108.7	0.5	+1.51	+98.9
6	4.7017	Paris (MESSIER)	−2.02	1	+ 19.5	1	−0.75	+12.7
7	6.7455	Paris (MESSIER)	−1.67	1	− 18.3	1	−0.02	−22.3
8	7.8068	Greenwich	−2.18	1	+ 14.1	1	−0.32	+10.6
9	11.3729	Greenwich	−3.99	1	−106.9	1	−1.03	−96.0
10	15.3189	Greenwich	−4.96 }	1	+ 24.3 }	1	−1.83 }	+38.1
11	15.3332	Paris (MÉCHAIN)	−4.17 }		+ 36.5 }		−1.04 }	+49.1
12	18.3606	Paris (MÉCHAIN)	−0.43	1	− 18.3	1	+3.02	+ 1.6
13	20.3759	Greenwich	−6.22	0.5	−125.4	0.5	−2.31	−99.8
14	23.4130	Greenwich			− 54.0	1		−21.0
15	23.4135	Greenwich	+4.39	0			+8.72	
16	25.3178	Greenwich	−2.69	1			+1.84	
17	25.3276	Greenwich			+ 44.0	1		+50.5
18	Feb. 3.7640	Greenwich	−4.27	0.5	−110.0	0.5	+1.07	−37.8
19	4.7494	Greenwich	−4.13	0.5	+ 7.3	0.5	+1.21	+88.0

The observations were grouped into five normal places as indicated by the horizontal lines in the preceding table which contains $\Delta\alpha \cos\delta$ and $\Delta\delta$ with the weights assigned to each. The values $\Delta\alpha \cos\delta$ II and $\Delta\delta$ II will be explained later. In general, equal weights were assigned to the daily means of each observer regardless of the number of observations combined in forming each mean. According to MASKELYNE's note the right ascension on January 23 was so erroneous that it was given weight zero and to a few other values one half weight was assigned for similar reasons. The Greenwich and Paris observations on January 15 were somewhat arbitrarily combined and given unit weight.

Ephemeris places for the normal dates were next computed with seven-place logarithms. Their values, with those of the weighted means deduced from the preceding, and the resulting normal places are given below.

TABLE III

No.	Berlin M. Time 1788-9	Ephemeris Place α	Ephemeris Place δ	O – C $\Delta\alpha$	O – C $\Delta\alpha\cos\delta$	O – C $\Delta\delta$	Normal Place α	Normal Place δ
		° ′ ″	° ′ ″	″	″	″	° ′ ″	° ′ ″
I	Dec. 26.0	278 17 28.2	+35 52 5.8	+ 21.0	+17.0	+14.2	278 17 49.2	+35 52 20.0
II	Jan. 6.0	276 37 34.0	43 48 21.9	– 24.4	–17.6	+19.9	276 37 9.6	43 48 41.8
III	Jan. 16.0	274 34 26.8	51 9 46.3	– 71.6	–44.9	–31.6	274 33 15.2	51 9 14.7
IV	Jan. 23.5	272 14 38.2	56 55 16.9	–106.1	–57.9	– 42.3	272 12 52.1	56 54 34.6
V	Feb. 4.0	265 31 24.5	66 2 18.2	–155.1	–62.9	–51.3	265 28 19.4	66 1 26.9

TABLE IV

No.	Berlin M. Time 1788-9	Perturbation $\Delta\alpha$	Perturbation $\Delta\alpha\cos\delta$	Perturbation $\Delta\delta$	O – C Corrected for Perturbations $\Delta\alpha$	O – C Corrected for Perturbations $\Delta\alpha\cos\delta$	O – C Corrected for Perturbations $\Delta\delta$	Σp α	Σp δ
		″	″	″	″	″	″		
I	Dec. 26.0	–0.2	–0.2	–0.4	+ 20.8	+16.8	+13.9	3	3
II	Jan. 6.0	– .3	– .2	– .7	– 24.7	–17.8	+19.2	3.5	3.5
III	Jan. 16.0	– .3	– .2	– .9	– 71.9	–45.1	–32.5	1.5	1.5
IV	Jan. 23.5	– .3	– .2	–1.0	–106.4	–58.1	–43.3	1.5	2.5
V	Feb. 4.0	– .3	– .1	–1.2	–155.4	–63.0	–52.5	1	1

TABLE V

RIGHT ASCENSION

$$9.96818n\,dS + 9.33627n\,dP + 9.07891\,dQ + 3.57161\,dT + 0.12111\frac{dq}{\sin 1''} + 9.17519n\frac{de}{2\sin 1''} = 1.06446\ (1.22531)$$

0.00159n	9.36552n	8.86861	3.56000	0.14981	9.22953n	1.25042n
0.02872n	9.34802n	8.57710	3.54115	0.16558	9.28110n	1.65418n
0.04124n	9.28108n	8.18825	3.53118	0.17340	9.32610n	1.95376n (1.76418n)
0.05781n	8.73366n	7.21926n	3.50716	0.17526	9.40177n	1.75664n (1.79934n)

DECLINATION

9.22106	9.64706n	9.38970	3.42139n	9.12560	9.58739	0.91381 (1.14301)
8.53297	9.80780n	9.31092	3.30057n	9.20165	9.67402	1.28330
8.78603n	9.91995n	9.14903	3.18235n	9.26706	9.72179	1.51188n
9.09026n	9.98870n	8.89587	3.07100n	9.32055	9.73320	1.63649n
9.37622n	0.06909n	8.55469n	2.73904n	9.17529	9.68966	1.72016n

The perturbations, though slight, were computed. In comparison with the inaccuracies of observation they are entirely negligible, but, as they were included in the solution, their values are given in Table IV with the corrected residuals and the weights.

In computing differential coefficients for the equations of condition SCHÖNFELD's formulæ were employed in the modified form given by BAUSCHINGER (page 160). The computations, which were made in duplicate, were further checked by computing geocentric places from the elements affected by increments of 100″ each. The relations of dP, dQ, and dS to the corrections of i, ϖ, and Ω are defined by the equations (BAUSCHINGER, page 135):

$$dP = \sin i \sin \varpi \, d\,\Omega + \cos \varpi \, di$$
$$dQ = \sin i \cos \varpi \, d\,\Omega - \sin \varpi \, di$$
$$dS = \cos i \, d\,\Omega + d\varpi$$

The unweighted equations of condition, for which the unit is the second of arc, the coefficients and the absolute terms being expressed logarithmically, are given below. As discovered later, erroneous values were used for n in the first, fourth fifth, and sixth equations. The values are given as used with the correct values in parentheses. As it was later deemed best to make a second solution, these errors have no effect upon the final results and, for that reason, were alllowed to stand without correction.

The equations in Table V were then multiplied by the square roots of the weights assigned above, and rendered homogeneous by the introduction of the quantities.

$$x = [0.27362]\, dS \qquad t = [3.83203]\, dT$$
$$y = [0.48767]\, dP \qquad u = [0.42184]\, \frac{dq}{\sin 1''}$$
$$z = [9.62826]\, dQ \qquad v = [9.94605]\, \frac{de}{2 \sin 1''}$$
$$l = [2.01480]\, n$$

The resulting equations of condition are: —

TABLE VI

$9.92682n\ x$	$+\ 9.38746n\ y$	$+\ 9.68921\ z$	$+\ 9.98444\ t$	$+\ 9.94083\ u$	$+\ 9.46770n\ v$	$=$	9.26122
0.00000n	9.44988n	9.51241	0.00000	0.00000	9.55551n		9.48065n
9.84314n	9.24839n	9.03688	9.80046	9.83178	9.42309n		9.70042n
9.85866n	9.18445n	8.64803	9.78749	9.83930	9.46809n		0.00000n
9.78449n	8.54599n	7.59400n	9.67543	9.75342	9.45872n		9.74484n
9.48600	9.69795n	0.00000	9.82792n	8.94232	9.87990		9.44057
8.53438	9.89216n	9.95469	9.74057n	9.05484	0.00000		9.51353
8.60045n	9.82032n	9.60884	9.43836n	8.93326	9.86378		9.55812n
9.01564n	0.00000n	9.46658	9.43794n	9.09768	9.98612		9.79366n
9.40260n	9.88442n	8.92643n	8.90704n	9.05345	9.74364		9.67836n

From these were obtained the following:

NORMAL EQUATIONS (coefficients natural numbers)

							I	II
$+3.1443\ x$	$+0.8656\ y$	$-0.6958\ z$	$-3.0545\ t$	$-3.0675\ u$	$+1.4298\ v$	$=$	+1.7055	−1.2684
+0.8656	+3.0684	−1.9356	+0.5452	−1.4391	−2.7574		+1.2047	−0.8734
−0.6958	−1.9356	+2.4280	−0.4658	+1.4053	+1.8948		+0.0280	+1.0457
−3.0545	+0.5452	−0.4658	+3.8268	+2.7672	−2.6947		−1.2601	+0.7361
−3.0675	−1.4391	+1.4053	+2.7672	+3.0769	−0.7357		−1.5831	+1.4100
+1.4298	−2.7574	+1.8948	−2.6947	−0.7357	+3.8090		−0.0757	+0.4668

ELIMINATION EQUATIONS (coefficients natural numbers)

							I	II
$3.1443\ x$	$+0.8656\ y$	$-0.6958\ z$	$-3.0545\ t$	$-3.0675\ u$	$+1.4298\ v$	$=$	+1.7055	−1.2684
	2.8301	−1.7441	+1.3853	−0.2948	−3.0684		+0.7353	−0.5242
		1.1992	−0.2874	+0.2448	+0.2508		+0.8586	+0.4120
			0.4184	−0.0067	−0.0362		+0.2407	−0.4396
				0.0033	−0.0063		−0.0014	+0.0260
					0.0006		−0.0058	−0.0254

As the coefficients of both u and v are small, the other four unknowns were expressed in terms of u and v, afterwards in terms of v alone and a solution effected by the method of OPPOLZER (Volume II, page 362).

$$\begin{aligned}
x &= +2.7799 \ +0.9996u \ -0.3269v = +1.3648 \ +1.5993v \\
y &= +0.0062 \ -0.0410u \ +0.8508v = +0.0642 \ -0.7719v \\
z &= +1.2032 \ -0.1906u \ -0.1359v = +1.4730 \ -0.5031v \\
t &= +2.0329 \ +0.0568u \ +0.3057v = +1.9529 \ +0.4118v \\
u &= -1.4158 \ +1.9269v
\end{aligned}$$

were the values used in substituting and the results obtained were as follows: —

$$\begin{aligned}
dS &= -1206''.7 & Q_{11}&[3.65144] \\
dP &= -\ 752\ .1 & Q_{22}&[2.99881] \\
dQ &= +2170\ .5 & Q_{33}&[2.63162] \\
dT &= -0^d.060603 & Q_{44}&[2.46952] \\
dq &= -0\ .005629 & Q_{55}&[3.30465] \\
de &= -0\ .016587 & Q_{66}&[3.22185] \\
d\Omega &= +1651''.3 \\
d\varpi &= -1917\ .3 \\
di &= -1748\ .0
\end{aligned}$$

Q_{11}, Q_{22} etc. are the reciprocals of the weights of x, y, z, t, u, and v respectively.

By this solution the sum of the squares of the residuals was reduced from 30464 to 2539 but the values found for the corrections are so large that it is evident the neglected terms of the second order would be appreciable and, therefore, the resulting elements would not represent the observations.

The orbit was, therefore, assumed to be a parabola and, de being placed equal to zero, the resulting values of the other corrections are as follows: —

$$\begin{aligned}
dS &= +80''.02 & d\Omega &= +367''.23 \\
dP &= +\ 1''.58 & d\varpi &= -\ 78\ .01 \\
dQ &= +38''.17 & di &= -189\ .35 \\
dT &= +0^d.031655 & pv &= \ 3347'' \\
dq &= -0\ .0002861
\end{aligned}$$

As the values of O — C used in the solution were large it seemed best before proceeding to discuss results to repeat the solution with new values for n. The last mentioned corrections were, therefore, applied to the elements MÉCHAIN II and a new system of elements found as follows: —

$$\begin{aligned}
T &= \text{November } 20.37140 \\
\varpi &= \ 30^\circ\ 24'\ 10''.0 \\
\Omega &= 352\ \ 30\ \ 33\ .2 \quad 1789.0 \\
i &= \ 64\ \ 27\ \ 14\ .7 \\
\log q &= 9.879111
\end{aligned}$$

All the observations were then compared with the positions of the comet derived from these new elements. The resulting values are given as $\Delta\alpha \cos\delta$ II and $\Delta\delta$ II in Table II. The new values of l and n are: —

log n (unweighted)	log n (weighted)	log l
0.72428	0.96284	9.53245
0.69020	0.96223	9.53184
0.44716	0.53520	9.10181
0.83885	0.92689	9.49650
1.23045	1.23015	9.80006
0.71608	0.95456	9.52417
1.15836	1.43039	0.00000
1.22789n	1.31593n	9.88554n
0.90819n	1.10746n	9.67707n
1.35411	1.35411	9.92372

$l = [1.43039]n$

As previously noted, this substitution of new values made it unnecessary to correct the errors in the original values of n.

With the above results new values were computed for the second members of the normal and elimination equations. They are given below, also as II in the preceding equations.

Normal Equations	Elimination Equations
−1.2684	−1.2684
−0.8731	−0.5242
+1.0157	+0.4120
+0.7361	−0.1396
+1.4100	+0.0260
+0.1668	−0.0251

Solving in u and v and later in v by substituting the following values: —

$$\begin{aligned}
x &= -1.6524 \ +0.9996u \ -0.3269v \\
&= +6.1351 \ +1.5976v \\
y &= +0.4295 \ -0.0410u \ +0.8508v \\
&= +0.0980 \ +0.7719v \\
z &= +0.0610 \ -0.1906u \ -0.1359v \\
&= -1.4809 \ -0.5028v \\
t &= -1.1791 \ +0.0566u \ +0.3057v \\
&= -0.7212 \ +0.4147v \\
u &= +8.0910 \ +1.9253v
\end{aligned}$$

there were found

$$
\begin{array}{llll}
dS = -92''.33 + 22.92e & = -1309''.4 & d\Omega & = +1311''.73 \\
dP = +\ 1\ .71 + 13.50e & = -\ 823\ .7 & d\varpi & = -1875\ .06 \\
dQ = -93\ .90 - 31.88e & = +1855\ .5 & di & = -1649\ .49 \\
dT = -0^d.002860 \quad +0.0016145e & = -0^d.103436 & pvv & = 516'' \\
dq = +0\ .0004000 \quad +0.000009519e & = -0\ .0054245 & & \\
d_e = & \quad -0\ .0180860 & &
\end{array}
$$

By this solution the sum of the squares of the residuals was reduced from 2450 to 516; but, as the coefficient of e in the last elimination equation was small and the values of the unknowns large, the latter are readily seen to be untrustworthy. As in the first solution the resulting elements would not represent the observations.

The assumption of parabolic motion was made, e being placed equal to zero in the values of the other unknowns with the following results: —

$$
\begin{array}{llll}
dS & = +92''.33 & d\Omega & = -\ 88''.80 \\
dP & = +\ 1\ .71 & d\varpi & = +130\ .62 \\
dQ & = -93\ .90 & di & = +\ 48\ .90 \\
dT & = -0^d.002860 & pvv & = 1634''.3 \\
dq & = +0\ .0004000 & II.5 & = 1632
\end{array}
$$

This parabola reduced the sum of the squares of the residuals from 2450 to 1634, a result which, in consideration of the obvious inaccuracy of the observations (especially in declination) might be deemed fairly satisfactory. The probable error of one normal place is $\pm 13''.6$. The value of *II*. 5 agrees with that found for *pvv* within the limits of accuracy of the computations and thus furnishes a check for the work.

As it was impossible to derive the true value of de from the least-squares solution, various values were arbitrarily assigned to this unknown and, with the resulting values of dT etc., were substituted in the weighted equations of condition, and the sum of the squares of the resulting residuals are: —

TABLE VII

Solution		*Ih*	Parabola	*Id*	*IId*	*IIId*	*B*
1000 de		+1.8086	0	−1.8086	−3.6172	−7.2344	−18.0864
$\Sigma\ p$	$\Delta\alpha \cos\delta$	131.2	140.2	152.5	165.1	191.0	311.1
	$\Delta\delta$	1730.8	1494.1	1271.7	1071.2	732.8	234.9
	Sum	1862.0	1634.3	1424.2	1236.3	926.8	546.0

It will be noticed that the reduction made by de is in the residuals of the declinations; and that the residuals in right ascension for the ellipse B (which, as noted above, does not at all represent the observations on account of neglected second order terms) are greatly increased.

Since the values of the unknowns in the first two assumptions of elliptical motion (*Id* and *IId*) were sufficiently small to warrant the expectation that the residuals found by substitution would agree closely with the corresponding residuals computed from the new systems of elements, those systems were found, the position of the comet for the normal dates computed from them and compared with the observed places for the same dates. Although the values of the unknowns in the third assumption were too large to satisfy the equations of condition the same computations were made for this assumption. As was expected the residuals showed no agreement. In the assumed hyperbola the agreement was quite within the limits of error of the computations. The accompanying Table VIII shows a comparison of the results obtained from the various systems of elements.

A review of the results obtained by the various solutions would seem to show that, owing to the inaccuracy of the existing observations of the comet 1788 II and the short period of visibility, during which the relative positions of the *Earth* and comet were unfavorable for an accurate determination of the orbit, it is impossible to determine the elements with any degree of certainty. The various systems deduced are shown in Table IX. The ellipse *IIId*, period 1066 years, which does not represent the observations, may be entirely neglected. The parabolic orbit or a slightly elliptical

TABLE VIII

DIFFERENCES (O — C)

Normal Place	Δα cos δ From Elements Ih	Δα cos δ From Equations	Δδ From Elements Ih	Δδ From Equations	Δα cos δ From Elements par	Δα cos δ From Equations	Δδ From Elements par.	Δδ From Equations
	"	"	"	"	"	"	"	"
I	+ 2.3	+2.5	− 5.6	− 5.4	+ 2.0	+2.4	− 5.4	− 1.9
II	− 1.5	−1.4	+12.9	+13.8	− 1.6	−1.2	+12.5	+12.7
III	− 5.6	−5.1	−17.8	−16.7	− 5.7	−5.4	−17.1	−16.2
IV	− 2.6	−1.9	− 8.1	− 9.3	− 3.0	−2.3	− 8.6	− 8.3
V	+ 6.0	+7.6	+18.1	+18.5	+ 7.7	+8.4	+16.3	+17.0

	From Elements Id	From Equations	From Elements Id	From Equations	From Elements IId	From Equations	From Elements IId	From Equations
	"	"	"	"	"	"	"	"
I	+ 2.7	+2.1	− 5.6	− 4.4	+ 3.4	+2.4	− 4.3	− 3.9
II	− 1.5	−1.0	+11.7	+11.7	+ 0.4	−0.9	+11.0	+10.6
III	− 6.5	−5.6	−16.5	−15.7	− 5.2	−5.8	−15.3	−15.2
IV	− 3.8	−2.8	− 6.4	− 7.1	− 3.2	−3.2	− 4.0	− 6.0
V	+ 7.5	+8.5	+15.8	+15.5	+10.4	+9.0	+11.6	+14.0

	From Elements IIId	From Equations	From Elements IIId	From Equations
	"	"	"	"
I	+ 5.5	+2.3	− 1.3	− 2.9
II	+ 2.5	−0.6	+12.5	+ 8.5
III	− 1.6	−6.0	−12.0	−14.2
IV	+ 0.1	−4.1	+ 0.3	− 3.7
V	+13.4	+9.9	+14.7	+11.0

TABLE IX

	Elements Ih	Parabola	Elements Id	Elements IId	Elements IIId
T	1788.Nov.20.37860	1788.Nov.20.36854	1788.Nov.20.35848	1788.Nov.20.34843	1788.Nov.20.32831
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
ϖ	30 29 11.2	30 26 20.6	30 23 0.1	30 19 39.5	30 12 58.4
1789.0 Ω	352 26 44.1	352 29 4.4	352 31 24.1	352 33 44.5	352 38 24.6
i	64 30 53.5	64 28 3.6	64 25 13.8	64 22 24.0	64 16 44.3
log q	9.879674	9.879341	9.879007	9.878673	9.878001
log e	0.000785		9.998194	9.996383	9.992766
Period			8564 years	3023 years	1066 years

Id, requiring about 8500 years for one revolution would satisfy the observations equally well. The hyperbola *Ih* gives results nearly as satisfactory, while the more elliptical orbit *IId*, requiring about 3000 years for a revolution, does no serious violence to the observations.

Yale University Observatory.

OBSERVATIONS OF THE SATELLITES OF *URANUS*, 1921,

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

BY ASAPH HALL.

[Communicated by Captain W. D. MACDOUGALL, U. S. Navy, Superintendent of U. S. Naval Observatory.]

Date	G. M. T.	p	G. M. T.	s	Comp.	Seeing	Power	Remarks
				Uranus Ariel				
	h m s	°	h m s	″				
1921 Aug. 29	16 12 24	161.80	16 47 29	13.86	2 , 4	g	195	*Ariel* ft. Interrupted by clouds and haze. Foggy. Clouded.
				Uranus Titania				
1921 Aug. 25	16 41 32	157.66	16 10 44	22.38	4 , 1	f	195	
26	17 57 8	165.15	17 55 50	31.68	4 , 1	g	195	
27	16 12 5	172.76	16 41 56	25.79	4 , 1	f g	195	Haze.
30	16 8 28	311.81	16 2 18	29.83	4 , 4	p-f	195	Haze. [by haze. Clouded.
Sept. 7	16 17 17	335.90	16 14 18	20.99	1 , 1	g	195	Very faint at times. Delayed
Oct. 14	14 25 6	353.51	14 25 37	25.03	5 , 5	g	195	Very faint. Moonlight. Haze.
17	13 35 10	162.90	13 31 50	29.68	5 , 5	g	195	Very faint. Moonlight. Haze.
18	13 10 10	171.19	13 39 0	29.00	4 , 4	f	195	Very faint. Moonlight. Haze.
21	13 25 38	338.40	13 26 35	25.65	4 , 4	f	195	[Clouded.
26	12 50 32	165.07	12 52 6	30.66	4 , 4	g	195	Faint. Haze.
Nov. 25	13 1 33	310.16	13 1 0	27.01	4 , 4	f g	195	Haze.
				Uranus-Oberon				
1921 Aug. 21	16 15 52	347.95	16 15 8	11.17	1 , 4	g	195	Haze.
25	17 38 19	353.43	17 38 42	31.75	4 , 4	p-f	195	
26	16 31 49	5.12	16 27 2	17.02	5 , 4	f-g	195	Very faint.
Sept. 8	15 55 35	358.20	15 57 40	25.71	1 , 4	g	195	Clouded. [and haze.
19	16 19 59	311.31	16 10 0	11.29	4 , 4	g	195	Faint. Interrupted by clouds
Oct. 1	13 47 42	333.21	13 45 33	25.94	1 , 4	f g	195	Faint.
2	14 7 48	310.97	13 59 15	37.60	1 , 4	g	195	Faint. Delayed by clouds and
21	12 15 7	170.18	12 17 48	39.33	4 , 4	g	195	Faint. Haze. [haze.
28	13 38 16	333.18	13 37 35	26.07	4 , 4	g	195	Faint. Haze.
Nov. 25	14 13 12	310.89	14 4 17	37.71	1 , 4	f	195	Delayed by clouds. Foggy.

U. S. Naval Observatory, Washington, D. C.
1921, Mar. 21.

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PARALLAXES OF FORTY-SIX STARS.

DETERMINED BY PHOTOGRAPHY WITH THE 26-INCH McCORMICK REFRACTOR.

By HAROLD L. ALDEN.

The present list of parallaxes is a continuation of those published in *A. J.* Nos. 778 and 796. It is given in the same form as the preceding lists with the addition of a column to facilitate reference to the remarks following the table. An asterisk following the catalog proper-motion indicates that the value has been taken from PORTER. The other columns are self-explanatory. Full details of the measures will appear in a future volume of the Publications of the Leander McCormick Observatory.

ι Draconis (R. A. $12^h\ 29.2^m$ Decl. $+70°\ 20'$) shows a large difference in proper-motion from the value given by Boss. No stars other than the three used as comparison stars were to be found on the plate suitable for testing for proper-motion of one or more of the comparison stars. The star *B. D.* 1 4637 (R. A. $22^h\ 33.9^m$ Decl. $+2°\ 6'$) failed to show appreciable proper-motion as indicated by the value assigned to it by PORTER in *A. J.* No. 268. A letter from PROF. PORTER states that later observations with the meridian circle have failed to confirm this motion and that the star is still under investigation.

The three *Cepheids* in the present list, *ζ Geminorum*, *l Vulpeculæ*, and *S Sagittæ* give a mean trigonometric parallax of $+0''.0017$. The mean relative parallax obtained spectroscopically for the same stars is $+0''.0023$.

No.	Star	1900 R. A.	1900 Decl.	Mag. and Spectrum	μ	Relative Parallax McCormick		Relative Parallax Spect. $-0''.005$	Proper-motion Observed	Proper-motion Boss	Notes
		h m	° ′		″	″	″	″	″	″	
296	Σ 3062 *Br.*	0 1.0	+57 53	6.1 G5	0.266	+0.001	±0.010	+0.043	+0.253	+0.262	*a*
297	*Lal.* 999	0 24.0	+ 2 31	7.4 G0	0.819	+ .002	± .008	+0.037	+0.817	+0.764*	
298	*Groom.* 145	0 43.2	+69 51	8.0 K0	0.415	+ .016	± .009	+0.039	+0.366	+0.362*	
299	*A. G. Hels.* 914	1 0.3	+63 21	8.7 K7	1.55	+ .098	± .013	+0.082	+1.523	+1.518*	
300	*W. B.* I^h 161	1 13.5	− 1 23	8.1 K0	0.489	+ .037	± .007	+0.035	+0.419	+0.401*	*b*
301	*Lal.* 2966	1 34.1	+66 25	7.6 G5	0.753	+ .031	± .009	+0.041	+0.697	+0.710*	
302	γ^1 *Andromedæ*	1 57.8	+41 51	2.3 K0	0.070	+ .013	± .008	+0.028	+0.034	+0.047	
303	γ^2 *Andromedæ*	1 57.8	+41 51	5.1 A0	0.072	+ .022	± .014		+0.039	+0.046	
304	Σ 305 *Ft.*	2 41.8	+18 57	7.9	0.176	+ .022	± .008	...	+0.077	+0.094*	*c*
305	Σ 305 *Br.*	2 41.8	+18 57	7.0 G0		+ .042	± .006	+0.027	+0.065		
306	95 *Ceti*	3 13.3	− 1 17	5.6 G5	0.251	+ .002	± .006	+0.017	+0.231	+0.247	*c*
307	π^5 *Orionis*	4 49.0	+ 2 17	3.9 B3	0.004	− .002	± .010	...	+0.008	−0.003	*d*
308	*A. G. Berlin* 1866	5 57.3	+19 23	9.0 F9	0.93	+ .017	± .009	+0.010	+0.699	+0.680*	
309	*Lal.* 13576	6 57.2	+29 30	6.0 F8	0.838	+ .060	± .011	+0.061	+0.126	+0.158	
310	*ζ Geminorum*	6 58.2	+20 43	4.0 G0p	0.009	+ .006	± .010	−0.002	+0.002	−0.004	
311	*β Canis Minoris*	7 21.7	+ 8 29	3.1 B8	0.066	+ .017	± .012	...	−0.047	−0.050	
312	69 *Geminorum*	7 29.8	+27 7	4.2 K5	0.119	+ .009	± .009	+0.013	−0.051	−0.027	
313	30 *Hydræ*	8 20.7	− 3 35	4.0 A0	0.071	+ .006	± .011	...	−0.078	−0.066	*d*
314	*Bradley* 1433	10 16.2	+41 44	5.9 F5	0.194	+ .055	± .011	+0.028	−0.137	−0.122	
315	*δ Leonis*	11 8.8	+21 4	2.6 A2	0.207	+ .073	± .008		+0.138	+0.148	

No.	Star	1900 R. A.	1900 Decl.	Mag. and Spectrum	μ	Relative Parallax McCormick		Relative Parallax Spect. $-0''.005$	Proper-motion Observed	Proper-motion Boss	Notes
		h m	° ′		″	″	″	″	″	″	
316	*κ Draconis*	12 29.2	+70 20	3.9 B5p	0.060	−0.007	±0.008	....	−0.008	−0.060	
317	*B. D.* −22 3557	13 13.8	−22 30	9.4	0.366	+ .029	± .015		−0.369		*e*
318	*Lal.* 26481 *B*	14 25.8	−15 11	7.9 G5	0.433	+ .034	± .014	+0.021	+0.198	+0.222*	*f*
319	Boss 3846	14 52.4	+ 0 44	5.7 K0	0.069	+ .017	± .012	+0.012	+0.077	+0.062	
320	6 *Serpentis*	15 16.0	+ 1 4	5.5 K0	0.125	+ .017	± .011	+0.013	−0.072	−0.054	
321	*ι Draconis*	15 22.7	+59 19	3.5 K0	0.010	+0.017	±0.010	+0.016	−0.011	−0.005	
322	*Lal.* 29617	16 10.4	− 8 6	5.6 G0	0.563	+0.069	±0.009	+0.061	+0.236	+0.227	
323	*α Ophiuchi*	17 30.3	+12 38	2.1 A5	0.263	+0.012	±0.009	....	+0.114	+0.117	
324	*B. D.* +26 3151	17 58.4	+26 20	7.1 K1	0.72	+0.070	±0.011	+0.055	+0.362	+0.377*	
325	*Nova Aquilæ* 3	18 43.8	+ 0 28			−0.015	±0.008	....	−0.008	......	
326	*U Vulpeculæ*	19 32.3	+20 7	7.0 G0p	0.031	−0.004	±0.009	−0.003	+0.009	....	
327	*S Sagittæ*	19 51.5	+16 22	5.8 G1p	0.004	0.000	±0.004	−0.003	+0.021	+0.003	*d*
328	*Lal.* 38626	20 3.6	+52 52	5.7 F4	0.334	+0.013	±0.010	+0.039	+0.217	+0.219	
329	17 *Sagittæ C*	20 5.5	+20 36	7.3 K1	0.011	−0.005	±0.011	+0.008	−0.003	−0.004	
330	17 *Sagittæ A*	20 5.5	+20 37	6.3 F2	0.114	+0.031	±0.007	+0.017	+0.036	+0.055	
331	*γ Equulei*	21 5.5	+ 9 44	4.8 F0	0.169	+0.039	±0.010	+0.004	+0.034	+0.053	
332	6 *Equulei*	21 5.7	+ 9 38	6.0 A2	0.018	−0.012	±0.009	......	+0.004	−0.007	
333	*W. B.* 21ʰ 594	21 26.0	+45 27	7.9 G8	0.56	+0.024	±0.007	+0.030	+0.398	+0.431*	*d*
334	*ρ Cygni*	21 30.2	+45 9	4.2 G5	0.099	+0.014	±0.013	+0.021	−0.039	−0.028	*d*
335	*π Pegasi*	22 5.5	+32 41	4.4 A9	0.026	0.000	±0.012	+0.010	−0.024	−0.013	*d*
336	1 *Lacertæ*	22 11.6	+37 15	4.2 K3	0.020	−0.007	±0.008	+0.012	−0.001	+0.020	
337	53¹ *Aquarii*	22 21.1	−17 15	6.7 G	0.258	+0.027	±0.015	+0.035	+0.284	+0.258	*c*
338	53² *Aquarii*	22 21.1	−17 15	6.4 G1	0.225	+0.044	±0.019	+0.033	+0.226	+0.225	
339	*B. D.* 1 4637	22 33.9	+ 2 0	9.5		−0.008	±0.010	......	+0.018	+0.540*	
340	*ε Pegasi*	22 59.8	+14 40	2.6 A	0.073	+0.012	±0.011	......	+0.066	+0.058	
341	Boss 5989	23 12.1	+52 40	5.6 F8	0.270	+0.074	±0.008	+0.011	+0.110	+0.146	

(*a*) Mean spectroscopic parallax for the system is given.

(*b*) Partly measured by Miss France.

(*c*) Spectroscopic parallax from unpublished manuscript kindly furnished by W. S. Adams.

(*d*) Partly measured by Miss Mott.

(*e*) See *A. J.* No. 788.

(*f*) Partly measured by Miss Darkow.

OBSERVATIONS OF MINOR PLANETS,

MADE AT ANN ARBOR WITH THE 12½-INCH REFRACTOR OF THE DETROIT OBSERVATORY,

By R. A. Rossiter, P. A. Smith, C. G. Ross, S. K. Proctor, Miss H. M. Losh and Miss M. E. Vosburg.

1921	G. M. T.	★	No. Comp.	Planet — ★ $\Delta\alpha$	Planet — ★ $\Delta\delta$	Planet's Apparent α	Planet's Apparent δ	Log $p\Delta$ for α	Log $p\Delta$ for δ	Obs'r.
				(9) Metis						
	h m s			m s	′ ″	h m s	° ′ ″			
Feb. 21	16 16 16.7	1	10 , 9	−0 25.63	+ 9 28.7	8 45 10.95	+27 16 35.3	7.5833	0.3514	*R*
				(19) Fortuna						
Oct. 28	15 26 44.6	2	12 , 13	+0 8.61	−11 13.2	2 5 43.97	+12 34 12.7	9.2990*n*	0.6512	*R*
Nov. 1	15 36 32.1	1	11 , 10	+0 8.36	+ 6 53.4	2 2 12.09	+12 10 13.1	9.1668*n*	0.6492	*R*

1921	G. M. T.	★	No. Comp.	Planet − ★ Δα	Planet − ★ Δδ	Planet's Apparent α	Planet's Apparent δ	Log pΔ for α	Log pΔ for δ	Obsr.
				(19) *Fortuna* (*Continued*)						
	h m s			m s	′ ″	h m s	° ′ ″			
Nov. 1	16 5 47.5	4	11 , 11	+0 7.44	+ 6 49.0	2 2 11.17	+12 10 38.2	8.9634n	0.6446	*S*
2	16 11 38.8	3	10 , 10	−0 44.48	+ 1 43.6	2 1 19.25	+12 5 3.3	8.8588n	0.6446	*S*
2	16 54 54.7	3	10 , 10	−0 45.99	+ 1 6.6	2 1 17.75	+12 4 56.2	7.6339n	0.5430	*P*
2	17 20 1.2	3	10 , 9	−0 46.85	+ 0 56.6	2 1 16.88	+12 4 46.7	8.7797	0.6412	*R*
				(4) *Vesta*						
Nov. 3	16 47 29.9	5	8 , 10	+0 4.80	− 6 35.2	3 16 55.67	+ 8 3 36.3	9.1372n	0.6957	*V*
3	16 20 33.2	5	10 , 10	+0 5.58	− 6 37.9	3 16 56.15	+ 8 3 33.5	9.3298n	0.6992	*L*
3	17 17 20.2	5	7 , 10	+0 3.65	− 6 29.0	3 16 54.52	+ 8 3 12.5	8.9118n	0.6925	*r*
3	18 5 38.8	5	11 , 9	+0 1.36	− 6 25.4	3 16 52.23	+ 8 3 46.0	8.0325	0.6917	*R*
Dec. 9	15 49 36.7	6	10 , 10	+0 7.63	+ 8 51.0	2 14 26.15	+ 7 21 56.8	8.9184	0.7007	*S*
10	17 13 16.1	6	10 , 10	−0 28.81	+10 32.2	2 13 49.71	+ 7 23 14.9	9.4198	0.7135	*S*
				(15) *Eunomia*						
Dec. 29	14 57 51.2	8	10 , 10	−0 2.78	− 8 7.1	7 25 59.58	+25 3 51.6	9.5828n	0.5630	*P*
1922										
Jan. 9	17 15 56.4	9	10 , 10	+0 6.09	−11 7.4	7 13 9.99	+24 28 46.4	8.5326n	0.4257	*L*
9	17 35 32.7	9	10 , 11	+0 5.08	−11 11.3	7 13 8.98	+24 28 42.5	7.8352	0.4246	*r*
9	17 59 3.2	9	10 , 11	+0 3.99	−11 12.8	7 13 7.89	+24 28 41.0	8.7478	0.4276	*R*
16	12 58 15.6	10	10 , 10	−0 12.39	− 9 53.1	7 5 35.40	+24 4 16.9	9.6149n	0.6074	*P*
16	13 21 15.4	10	12 , 12	−0 13.80	− 9 58.9	7 5 33.99	+24 4 11.4	9.5856n	0.5813	*r*
16	13 41 22.2	10	11 , 10	−0 14.39	−10 0.7	7 5 33.40	+24 4 8.3	9.5560n	0.5605	*R*
16	14 23 11.2	10	10 , 10	−0 16.75	−10 7.2	7 5 31.04	+24 4 2.8	9.4691n	0.5169	*V*
16	14 48 17.8	10	11 , 10	−0 17.44	−10 9.2	7 5 30.35	+24 4 0.8	9.4053n	0.4955	*L*
23	14 2 39.2	12	10 , 11	−0 51.78	−10 15.9	6 58 32.91	+23 37 4.8	9.4557n	0.5084	*R*
23	14 31 59.3	12	10 , 10	−0 53.02	−10 21.9	6 58 31.56	+23 36 58.8	9.3492n	0.4847	*L*
25	13 20 24.5	13	10 , 10	+0 47.48	− 3 27.7	6 56 46.02	+23 29 20.9	9.5147n	0.5452	*R*
25	14 35 28.8	13	13 , 10	+0 47.65	− 3 37.3	6 56 43.19	+23 29 11.3	9.2868n	0.4814	*r*
26	14 20 35.4	13	18 , 11	−0 6.70	− 7 35.5	6 55 52.14	+23 32 37.3	9.3325n	0.4882	*L*
				(78) *Diana*						
Jan. 6	17 41 45.7	11	11 , 12	+0 46.81	+ 7 53.1	6 57 0.01	+35 14 11.6	8.5929	0.0246	*R*
7	11 1 31.7	14	10 , 11	−0 14.50	+ 5 34.5	6 56 1.71	+35 11 53.0	9.9558n	0.5306	*S*
7	14 15 32.9	14	11 , 12	−0 13.70	+ 5 30.6	6 55 59.51	+35 11 49.4	9.5291n	0.2813	*R*
9	15 39 28.9	15	10 , 10	−0 29.59	− 5 20.7	6 53 39.22	+35 5 28.8	9.3266n	0.1401	*L*
9	16 4 11.0	15	10 , 10	−0 31.13	− 5 22.1	6 53 37.39	+35 5 27.1	9.1956n	0.0925	*r*
9	16 18 23.9	15	10 , 10	−0 31.50	− 5 23.6	6 53 37.32	+35 5 25.9	9.0975n	0.0703	*R*
9	16 33 57.2	15	10 , 10	−0 32.31	− 5 25.7	6 53 36.51	+35 5 22.8	8.9530n	0.0509	*S*
19	15 13 23.9	16	9 , 10	−0 15.32	+10 21.1	6 13 8.02	+34 22 16.2	8.9579n	0.0916	*R*
21	14 13 6.7	17	11 , 13	+0 17.12	−10 49.4	6 41 23.16	+34 11 40.5	9.4215n	0.2310	*r*
21	14 37 33.7	17	12 , 10	+0 16.32	−10 55.3	6 41 22.36	+34 11 34.6	9.3367n	0.1993	*P*
21	14 59 1.6	17	11 , 12	+0 15.58	−10 57.5	6 41 21.62	+34 11 32.4	9.2218n	0.1457	*R*
				(64) *Angelina*						
Jan. 9	19 13 28.4	19	10 , 10	+0 23.54	+ 2 0.1	7 11 13.10	+23 18 16.1	9.3199	0.4866	*R*
9	21 23 8.7	19	11 , 10	+0 19.23	+ 2 3.7	7 11 38.79	−23 18 19.7	9.5020	9.8191	*S*
16	16 10 24.8	20	10 , 11	+0 40.23	+ 1 14.9	7 4 50.15	+23 24 48.1	8.9638n	0.4568	*V*

1921	G. M. T.	★	No. Comp.	Planet − ★ $\Delta\alpha$	$\Delta\delta$	Planet's Apparent α	δ	Log $p\Delta$ for α	for δ	Observer
					(61) *Angelina (Continued)*					
	h m s			m s	′ ″	h m s	° ′ ″			
Jan. 16	16 36 52.7	20	9 , 10	+0 38.97	+ 1 47.4	7 1 48.89	+23 21 50.6	8.6065*n*	0.4507	*L*
16	17 24 33.6	20	11 , 12	+0 37.21	+ 1 48.1	7 1 47.13	+23 21 51.2	8.7656	0.1522	*R*
26	15 6 59.9	13	10 , 10	+0 3.42	− 2 46.6	6 56 2.26	+23 30 2.1	9.0993*n*	0.1615	*R*
					(13) *Egeria*					
Jan. 21	16 16 39.5	24	10 , 10	+0 5.55	− 5 51.8	9 13 57.15	+11 52 31.6	9.1844*n*	9.2571	*r*
21	17 5 36.5	24	10 , 10	+0 4.33	− 5 42.8	9 13 55.94	+14 52 40.6	9.4144*n*	7.6637	*R*
24	14 10 14.4	22	10 , 10	−0 36.54	− 3 13.9	9 10 36.42	+45 44 34.7	9.7483*n*	0.3447	*R*
24	14 27 53.5	22	10 , 10	−0 37.42	− 3 8.9	9 10 35.54	+45 44 39.6	9.7341*n*	0.2767	*r*
25	15 1 52.5	23	10 , 10	+0 1.11	+ 5 16.7	9 9 21.61	+45 17 40.7	9.6813*n*	0.0882	*R*
Feb. 13	14 13 21.1	24	10 , 10	+0 17.16	−13 51.4	8 16 23.24	+15 59 27.4	9.5924*n*	9.6335	*R*
13	14 40 22.5	24	12 , 11	+0 14.38	−13 55.1	8 16 20.16	+15 59 26.4	9.5183*n*	9.0272	*S*
					(11) *Parthenope*					
Jan. 26	16 23 16.5	26	10 , 11	+0 16.79	− 3 48.3	8 33 13.72	+18 54 0.1	9.2026*n*	0.5552	*R*
27	13 11 1.6	25	12 , 11	−0 30.64	− 9 46.2	8 32 21.95	+18 58 31.1	9.6233*n*	0.6728	*R*
27	13 50 54.1	25	10 , 10	−0 32.41	− 9 37.2	8 32 20.19	+18 58 40.1	9.5897*n*	0.6470	*P*
27	14 13 33.3	25	12 , 10	−0 34.09	− 9 32.3	8 32 18.54	+18 58 45.0	9.5538*n*	0.6266	*S*

R. A. ROSSITER = *R*, P. A. SMITH = *S*, C. G. ROSS = *r*, S. K. PROCTOR = *P*, MISS H. M. LOSH = *L*, MISS M. E. VOSBURG = *V*.

Mean Places for 1921 of Comparison Stars

★	α	Red. to App. Pl.	δ	Red. to App. Pl.	Authority
	h m s	s	° ′ ″	″	
1	8 16 4.17	+2.11	+27 7 20.5	−13.9	*A. G. Cambridge* 4707
2	2 5 31.02	+4.34	+12 48 8.0	+17.9	*A. G. Leipsig I* 636
3	1 58 51.62	+4.33	+11 58 2.0	+18.4	*A. G. Leipsig I* 612
4	2 1 59.40	+4.33	+12 3 31.3	+18.4	9.1 mag. Connected with ★ 3 $\Delta\alpha = +3^m\ 7^s.78$ $\Delta\delta = +5'\ 29''.3$
5	3 16 46.56	+4.31	+ 8 10 0.4	+11.4	*A. G. Leipsig II* 1241
6	2 44 14.13	+4.39	+ 7 42 30.3	+12.4	*A. G. Leipsig II* 1037
7	7 26 10.26	+5.32	+25 19 55.3	−20.1	*A. G. Cambridge* 4005
8	7 25 57.01	+5.32	+25 12 18.8	−20.1	9.5 mag. Connected with ★ 7 $\Delta\alpha = -0^m\ 13^s.22$ $\Delta\delta = -7'\ 36''.5$

Mean Places for 1922 of Comparison Stars

★	α	Red. to App. Pl.	δ	Red. to App. Pl.	Authority
9	7 13 2.06	+1.84	+24 40 6.4	−12.3	*A. G. Berlin B* 2876
10	7 5 45.89	+1.90	+24 41 21.9	−11.9	*A. G. Berlin B* 2841
11	7 0 27.69	+1.92	+23 49 47.8	−11.8	*A. G. Berlin B* 2756
12	6 59 22.77	+1.92	+23 47 32.5	−11.8	9.4 mag. Connected with ★ 11 $\Delta\alpha = -1^m\ 4^s.92$ $\Delta\delta = -1'\ 15''.3$

★	α	Red. to App. Pl.	δ	Red. to App. Pl.	Authority
	h m s	s	° ′ ″	″	
13	6 55 56.92	+1.92	+23 33 0.2	−11.6	*A. G. Berlin B* 2720
14	6 56 11.21	+1.99	+35 6 29.9	−11.4	*A. G. Lund* 3635
15	6 54 6.80	+2.02	+35 11 0.7	−11.2	*A. G. Lund* 3614
16	6 43 21.27	+2.07	+34 12 4.9	− 9.8	*A. G. Leiden* 2826
17	6 41 3.96	+2.08	+34 22 39.5	− 9.6	*A. G. Leiden* 2808
18	7 10 28.93	+1.85	+23 22 25.6	−12.3	*A. G. Berlin B* 2851
19	7 11 17.71	+1.85	+23 16 28.3	−12.3	10.5 mag. Connected with ★ 18 $\Delta\alpha = +0^m\ 48^s.80\ \ \Delta\delta = -5'\ 57''.3$
20	7 4 8.03	+1.89	+23 23 45.1	−12.0	*A. G. Berlin B* 2802
21	9 13 49.67	+1.91	+41 58 39.6	−16.2	*A. G. Bonn* 7044
22	9 11 10.91	+2.02	+45 15 4.4	−15.8	*A. G. Bonn* 7023
23	9 9 18.46	+2.04	+45 12 9.7	−15.7	*A. G. Bonn* 7002
24	8 46 3.47	+2.31	+46 13 32.7	−11.5	*A. G. Bonn* 6809
25	8 32 50.73	+1.86	+19 8 31.8	−14.5	*A. G. Berlin A* 3428
26	8 32 55.07	+1.86	+18 58 2.9	−14.5	9.5 mag. Connected with ★ 25 $\Delta\alpha = +0^m\ 43^s.4\ \ \Delta\delta = -10'\ 28''.9$

OBSERVATIONS OF THE SATELLITES OF *SATURN*, 1911-12.

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

By ASAPH HALL and H. E. BURTON.

[Communicated by Captain W. D. MacDougall, U. S. Navy, Superintendent, U. S. Naval Observatory.]

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Obs.	Remarks
				Mimas–Tethys					
	h m s	°	h m s	″					
1911 Sept. 6	15 45 17	109.02			4 . 0	3	367. Red	Bn	Clouded.
24	13 12 19	49.85	13 12 30	24.90	4 . 4	3	367p. Red	Bn	Haze at times.
24	13 42 58	42.00	13 43 10	23.28	4 . 4	3	367p. Red	Bn	
Oct. 13	11 45 38	13.05	11 45 34	22.62	4 . 4	2	367. Brt.	Bn	
13	12 11 10	1.62	12 10 2	22.73	4 . 4	2	367. Brt.	Bn	
25	15 9 33	119.64	15 11 13	38.39	4 . 4	2-3	367. Brt.	Bn	
25	15 28 29	116.38	15 29 28	39.98	4 . 4	2-3	367. Brt.	Bn	
Dec. 6	12 18 58	92.22	12 20 5	20.01	4 . 4	1-2	367. Brt.	Bn	Bright moonlight.
6	12 37 2	93.10	12 38 18	19.68	4 . 4	1-2	367. Brt.	Bn	
19	7 33 32	119.30	7 32 40	30.01	4 . 4	2-3	367. Brt.	Bn	
19	8 1 58	114.77	8 3 3	31.86	4 . 4	2-3	367. Brt.	Bn	
				Mimas–Rhea					
1911 Sept. 6	15 3 51	289.50	15 20 19	12.87	4 . 4	2-3	367. Red	Bn	Moonlight. Haze.
24	12 19 42	301.18	12 20 58	33.71	4 . 4	2	367p. Red	Bn	
24	12 42 9	301.92	12 42 51	34.57	4 . 4	2	367p. Red	Bn	
Oct. 13	11 7 29	260.56	11 7 36	52.79	4 . 4	2	367. Brt.	Bn	
13	11 22 2	260.95	11 22 23	53.11	4 . 4	2	367. Brt.	Bn	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Obs.	Remarks
				Mimas-Rhea (Continued)					
	h m s	°	h m s	"					
1911 Oct. 26	15 7 31	275.94	15 8 57	57.32	1 . 4	3	367, Brt.	Bn	
26	15 26 51	276.33	15 29 9	58.15	1 . 4	3	367, Brt.	Bn	
Nov. 16	8 17 57	80.34	8 18 53	112.00	1 . 4	3	367, Brt.	Bn	
16	9 7 1	79.37	9 6 22	111.21	4 . 4	3	367, Brt.	Bn	
				Enceladus-Tethys					
1911 Sept. 6	11 7 47	231.59	11 20 52	35.41	4 . 4	3	367, Brt.	Hl	
20	14 29 16	83.68	14 29 21	26.71	1 . 4	2-3	388, Red	Hl	
20	14 55 12	82.08	14 57 16	27.31	1 . 4	2-3	388, Red	Hl	
30	12 8 15	323.39	12 7 7	10.86	1 . 4	2-3	367p. Red	Hl	
30	12 39 15	315.38	12 40 44	14.99	1 . 4	2-3	367p. Red	Hl	
Oct. 13	12 18 18	279.00	12 48 58	67.69	1 . 4	2	367, Brt.	Hl	*Enceladus* very
25	13 51 37	259.82	13 53 20	25.18	4 . 4	2	367p. Brt.	Hl	[faint. Haze.
25	14 26 29	257.19	14 25 49	25.20	1 . 4	2	367p. Brt.	Hl	
26	10 14 56	76.36	10 38 6	55.18	4 . 3	2	367p. Brt.	Hl	Very faint at
26	14 32 7	49.14	14 31 49	37.71	1 . 4	2	367p. Brt.	Hl	[times. Haze.
Nov. 1	11 3 58	291.52	11 6 14	63.91	1 . 4	3-4	367p. Brt.	Hl	[out.
1	11 48 31	287.14	11 39 14	68.86	1 . 3	3-4	367p. Brt.	Hl	*Enceladus* went
Dec. 1	9 0 3	234.88	9 2 32	9.82	4 . 4	3	367, Brt.	Hl	Windy. Brt.
4	9 36 23	228.91	9 37 7	9.79	1 . 4	3	367, Brt.	Hl	[moonlight.
5	8 7 13	27.31	8 10 6	21.65	4 . 4	2-3	367, Brt.	Hl	Bright moonlight.
5	8 35 58	16.22	8 36 12	23.50	1 . 4	2-3	367, Brt.	Hl	
				Tethys-Dione					
1911 Sept. 12	14 22 39	289.77	14 33 51	73.43	1 . 4	1	367p. Brt.	Bn	Moonlight.
12	14 51 14	287.86	14 42 49	71.59	1 . 4	4	367p. Brt.	Bn	
13	14 12 18	134.31	14 59 58	31.14	4 . 4	3-4	195p. Brt.	Bn	
13	15 5 14	130.95	14 57 54	31.53	1 . 4	3-4	195p. Brt.	Bn	
16	16 2 37	209.07	16 12 15	36.89	1 . 4	4	367p. Brt.	Bn	
16	16 26 25	203.38	16 18 19	36.32	1 . 4	1	367p. Brt.	Bn	
20	13 26 33	301.79	13 36 0	43.64	4 . 4	3	367p. Brt.	Bn	
20	13 51 20	300.88	13 45 8	43.59	4 . 4	3	367p. Brt.	Bn	
Oct. 14	14 6 53	110.88	14 7 26	77.14	1 . 4	1	367p. Brt.	Bn	
14	14 27 37	109.14	14 29 10	79.91	1 . 4	1	367p. Brt.	Bn	
12	11 58 23	343.93	12 0 23	11.10	1 . 4	3	367p. Brt.	Bn	
12	12 21 34	337.64	12 21 10	12.72	4 . 4	3	367p. Brt.	Bn	Clouded.
Nov. 4	13 16 31	203.09	13 46 51	21.13	4 . 4	3-4	367p. Brt.	Bn	
4	14 7 24	204.02	14 8 28	20.91	1 . 4	3-4	367p. Brt.	Bn	
15	8 48 59	270.56	8 48 57	11.48	4 . 4	1	367p. Brt.	Bn	
15	9 8 17	270.27	9 9 8	15.17	4 . 4	1	367p. Brt.	Bn	Clouded.
22	12 48 29	61.18	12 48 50	57.46	4 . 4	2-3	367p. Brt.	Bn	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Obs.	Remarks
				Tethys–Dione (Continued)					
	h m s	°	h m s	″					
1914 Nov. 22	13 6 26	59.66	13 6 50	55.68	4 . 4	2–3	367p. Brt.	Bn	
30	8 37 49	66.44	8 38 19	74.25	4 . 4	3–4	367p. Brt.	Bn	
30	8 57 20	64.74	8 56 5	71.88	4 . 4	3–4	367p. Brt.	Bn	
				Tethys–Rhea					
1914 Sept. 11	14 32 58	257.27	14 41 43	12.03	4 . 4	2–3	495p. Brt.	Bn	
11	15 0 30	256.98	14 52 43	12.00	4 . 4	2–3	495p. Brt.	Bn	Objective fogged.
16	12 56 48	257.96	13 8 54	116.62	4 . 4	4	367p. Brt.	Bn	
16	13 28 36	256.73	13 18 19	115.92	4 . 4	4	367p. Brt.	Bn	
20	12 35 30	263.73	12 48 7	111.40	4 . 4	3–4	367p. Brt.	Bn	
20	13 8 59	262.73	12 57 11	110.70	4 . 4	3–4	367p. Brt.	Bn	
26	11 38 50	135.09	11 49 8	65.28	4 . 4	3–4	367p. Brt.	Bn	
26	12 4 16	131.71	11 56 36	66.35	4 . 4	3–4	367p. Brt.	Bn	
Oct. 11	15 0 23	80.53	15 0 42	75.75	4 . 4	3	367p. Brt.	Bn	
11	15 13 26	80.18			2 . 0	3	367p. Brt.	Bn	Clouded.
12	14 12 54	292.61	14 13 29	95.22	4 . 4	2–3	367p. Brt.	Bn	
12	14 31 51	291.50	14 32 11	97.38	4 . 4	2–3	367p. Brt.	Bn	Clouded.
Nov. 5	9 23 25	194.50	9 23 40	30.56	4 . 4	2	495p. Brt.	Bn	Moonlight.
5	9 10 45	191.54	9 40 31	29.90	4 . 4	2	495p. Brt.	Bn	Clouded.
16	11 38 39	87.17	11 39 46	98.61	4 . 4	3	495p. Brt.	Bn	
16	11 59 36	86.58	11 59 36	99.55	4 . 4	3	495p. Brt.	Bn	
25	9 50 25	75.88	9 51 11	34.39	4 . 4	2–3	367p. Brt.	Bn	
25	10 6 23	76.41	10 7 7	34.40	4 . 4	2–3	367p. Brt.	Bn	
Dec. 1	11 5 48	268.19	11 7 39	69.06	4 . 4	3–4	367p. Brt.	Bn	Haze.
1	11 26 9	267.77	11 26 35	67.81	4 . 4	3–4	367p. Brt.	Bn	
				Dione–Rhea					
1914 Sept. 13	15 32 3	81.65	15 47 44	102.41	4 . 4	4	495p. Brt.	Hl	
13	16 7 15	80.57	15 57 53	101.74	4 . 4	4	495p. Brt.	Hl	
26	12 23 48	117.45	12 37 46	91.76	4 . 4	3–4	367p. Brt.	Hl	
26	12 58 17	115.57	12 48 11	92.93	4 . 4	3–4	367p. Brt.	Hl	
Oct. 14	11 22 36	29.00	11 22 49	45.73	4 . 4	4	495p. Brt.	Hl	Moonlight.
14	11 58 51	23.63	11 59 35	43.23	4 . 4	4	495p. Brt.	Hl	
13	15 24 42	269.88	15 21 9	36.06	4 . 4	2	367p. Red	Hl	Faint. Haze.
18	12 47 41	145.72	12 48 20	14.07	4 . 4	3	367p. Brt.	Hl	
18	13 19 30	141.41	13 19 38	15.58	4 . 4	3	367p. Brt.	Hl	
23	11 46 20	157.32	11 45 2	58.10	4 . 4	4	367p. Brt.	Hl	
23	12 15 4	152.86	12 15 50	60.34	4 . 4	4	367p. Brt.	Hl	
29	12 43 21	81.30	12 45 1	128.25	4 . 4	3–4	367p. Brt.	Hl	
29	13 20 1	80.23	13 22 31	127.06	4 . 4	3–4	367p. Brt.	Hl	
Nov. 21	10 21 29	355.20	10 20 10	18.91	4 . 4	3	367p. Brt.	Hl	
21	10 51 42	349.23	10 49 56	19.03	4 . 4	3	367p. Brt.	Hl	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Obs.	Remarks
				Dione-Rhea (Continued)					
	h m s	°	h m s	"					
1911 Nov. 30	11 10 57	317.90	11 9 47	15.87	1, 4	3–4	367p, Brt.	HI	
30	11 39 21	315.10	11 51 53	15.33	2, 4	3–4	367p. Brt.	HI	Stopped by haze.
Dec. 17	9 23 51	103.98	9 25 2	115.30	1, 4	3	367p. Brt.	HI	
17	10 9 24	102.28	10 12 11	120.08	1, 4	3	367p. Brt.	HI	
				Rhea-Titan					
1911 Sept. 11	13 6 50	11.636	13 25 31	99.10	4, 4	3	495,p Brt.	HI	Moonlight. Misty.
11	13 57 41	12.917	13 38 23	98.93	4, 4	3	495p. Brt.	HI	
12	13 1 47	322.662	13 11 43	115.52	4, 4	4	495p. Brt.	HI	Moonlight.
12	13 35 49	324.021	13 21 55	116.66	4, 4	4	495p. Brt.	HI	Clouds. Probably [p should be de-[creased 3°.
16	15 0 57	257.157	15 13 33	99.55	4, 4	4	367p. Brt.	HI	
16	15 33 56	257.208	15 23 37	99.28	4, 4	4	367p. Brt.	HI	
30	13 6 18	284.317	13 26 19	170.84	4, 4	3	495p. Brt.	HI.	
30	13 55 7	283.837	13 44 57	172.05	4, 4	3	495p. Brt.	HI	
Oct. 1	15 30 18	142.602	15 31 17	67.17	4, 4	4	495p. Brt.	HI	Windy.
1	15 52 49	142.119	15 52 6	66.89	4, 4	4	495p. Brt.	HI	
11	12 35 13	61.394	12 35 52	76.59	4, 4	3–4	495p. Brt.	HI	Clouds.
11	13 19 36	61.983	13 19 11	77.04	4, 4	3–4	495p. Brt.	HI	
13	13 41 21	26.672	13 41 50	99.84	4, 4	2–3	495p. Brt.	HI	*Rhea* faint. Haze.
13	14 20 16	24.[illegible]97	14 20 30	98.88	4, 4	2–3	495p. Brt.	HI	
16	10 51 27	264.124	10 56 29	209.21	4, 4	2	367p. Brt.	HI	
16	11 33 15	264.049	11 36 34	206.49	4, 4	2	367p Brt.	HI	Foggy.
18	10 37 20	262.064	10 37 36	122.25	4, 4	3	367p. Brt.	HI	
18	11 10 26	262.227	11 11 23	123.87	4, 4	3	367p. Brt.	HI	
26	13 19 29	81.812	13 18 5	264.70	4, 4	2	367p. Brt.	HI	
26	13 56 49	81.128	13 56 14	264.18	4, 4	2	367p. Brt.	HI	
Nov. 1	11 48 55	278.229	11 47 4	232.51	4, 4	3	367p. Brt.	HI	Clouds.
2	9 46 50	266.578	9 46 26	285.14	4, 4	3	367p. Brt.	HI	
2	10 21 3	266.173	10 20 21	285.26	4, 4	3	367p. Brt.	HI	
13	10 49 30	64.664	10 49 54	137.06	4, 4	2–3	367p. Brt.	HI	Thick haze.
13	11 33 45	63.957	11 36 8	136.99	4, 4	2–3	367p. Brt.	HI	Satellites went out.
18	10 11 46	261.758	10 10 49	108.02	4, 4	4	367p. Brt.	HI	
18	11 17 41	262.028	11 17 47	107.95	4, 4	4	367p. Brt.	HI	
22	11 28 25	115.118	11 32 54	176.35	4, 4	2–3	367p. Brt.	HI	
22	15 2 30	114.[illegible]	15 3 59	177.92	4, 4	2–3	367p. Brt.	HI	
25	10 49 30	100.259	10 51 9	135.15	4, 4	2–3	367p. Brt.	HI	
25	11 31 1	100.251	11 30 51	137.25	4, 4	2–3	367p. Brt.	HI	
Dec. 7	10 22 28	187.184	10 21 47	91.61	4, 4	2	495p. Brt.	HI	Brt. moonlight.
7	10 58 14	188.558	10 57 15	91.28	4, 4	2	495p. Brt.	HI	
8	11 17 16	191.185	11 17 16	63.54	4, 4	2–3	367p. Brt.	HI	Moonlight.
8	11 53 27	192.936	11 51 59	63.94	4, 4	2–3	367p. Brt.	HI	Clouded.

Rhea–Titan (Continued)

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Obs.	Remarks
	h m s	°	h m s	″					
1911 Dec. 10	10 34 36	100.371	10 38 31	262.15	4 , 4	2	367p, Brt.	Hl	
10	11 23 57	99.748	11 28 8	265.11	4 , 4	2	367p, Brt.	Hl	
18	9 46 26	270.725	9 46 6	213.73	4 , 4	3	367p, Brt.	Hl	
18	10 25 54	270.309	10 25 43	211.28	4 , 4	3	367p, Brt.	Hl	
1912 Jan. 10	7 36 36	121.049	7 39 25	151.66	4 , 4	3	367p, Brt.	Hl	
10	8 14 23	120.036	8 14 28	154.95	4 , 4	3	367p, Brt.	Hl	
19	7 27 1	269.474	7 30 45	173.01	4 , 4	3	367p, Brt.	Hl	
19	8 5 23	269.222	8 11 5	170.76	4 , 4	3	367p, Brt.	Hl	
20	8 51 6	267.186	8 54 32	104.67	4 , 4	2	367p, Brt.	Hl	
20	9 26 58	267.360	9 26 56	104.07	4 , 4	2	367p, Brt.	Hl	
24	7 40 9	153.872	7 42 37	99.08	4 , 4	3–4	367p, Brt.	Hl	Windy.
24	8 23 58	151.188	8 24 55	100.56	4 , 4	3–4	367p, Brt.	Hl	
27	7 37 9	107.196	7 39 29	97.21	4 , 4	3	367p, Brt.	Hl	
27	8 15 4	107.330	8 15 47	98.54	4 , 4	3	367p, Brt.	Hl	

Titan–Hyperion

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Obs.	Remarks
1911 Oct. 24	13 34 5	198.894	13 36 41	56.68	4 , 4	3	367b, Red	Hl	*Hyperion* very ft.
24	14 13 43	198.450	14 17 15	56.28	4 , 4	3	367b, Red	Hl	
25	10 53 42	166.573	10 54 56	60.59	4 , 4	2	367b, Red	Hl	
25	11 31 11	165.562	11 34 15	61.40	4 , 4	2	367b, Red	Hl	
Dec. 6	10 10 0	86.680	10 14 58	303.77	4 , 4	2	367b,	Hl	*Hyperion* very ft. [Haze.
6	11 10 58	86.264	11 7 34	302.13	4 , 4	2	367b,	Hl	Brt. moonlight.
7	9 14 38	79.622	9 26 22	256.98	3 , 5	2	367b, Red	Hl	Stopped by moon- [light.
1912 Jan. 21	7 39 33	80.482	7 46 27	366.57	4 , 4	2	367b, Red	Hl	
22	7 55 53	69.628	7 58 26	289.11	4 , 4	3	367b, Red	Hl	

Titan–Japetus

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Obs.	Remarks
1911 Sept. 13	13 40 1	194.565	13 52 49	210.31	4 , 4	2–3	367, Red	Hl	Moonlight.
13	14 13 6	194.272	14 2 26	210.42	4 , 4	2–3	367, Red	Hl	
16	14 5 1	148.807	14 24 0	152.19	4 , 4	4	367p, Red	Hl	Star observed for [Japetus?
16	14 42 25	148.633	14 33 5	151.84	4 , 4	4	367p, Red	Hl	
20	15 36 13	190.451	15 51 46	72.39	4 , 4	3	195p, Brt.	Hl	
20	16 14 50	190.905	16 0 8	72.65	4 , 4	3	195p, Brt.	Hl	
Oct. 23	13 16 53	10.669	13 15 33	251.28	4 , 4	3	367p, Brt.	Bn	
23	13 46 25	10.364	13 44 52	253.13	4 , 4	3	367p, Brt.	Bn	
24	15 17 7	352.273	15 17 37	216.02	4 , 4	3–4	367p, Brt.	Bn	
24	15 44 2	351.891	15 46 55	215.20	4 , 4	3–4	367p, Brt.	Bn	
25	12 26 25	339.878	12 26 40	194.23	4 , 4	1–2	367p, Brt.	Bn	
25	12 53 11	339.576	12 52 56	194.09	4 , 4	1–2	367p, Brt.	Bn	
26	11 56 16	331.029	11 56 29	170.12	4 , 4	2–3	367p, Brt.	Bn	
26	12 25 32	330.872	12 26 26	169.48	4 , 4	2–3	367p, Brt.	Bn	
29	10 33 56	273.103	10 31 17	88.90	4 , 4	3–4	367p, Brt.	Bn	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Obs.	Remarks
			Titan–Japetus (Continued)						
	h m s		h m s	″					
1911 Oct. 29	11 0 38	353.576	11 0 33	88.73	4, 4	3–4	367p. Brt.	Bn	
Nov. 1	9 47 56	11.821	9 49 29	111.29	4, 4	2–3	367p. Brt.	Bn	
1	10 9 42	11.616	10 9 35	111.42	4, 4	2–3	367p. Brt.	Bn	
2	11 6 39	348.935	11 6 44	126.41	4, 4	3	367p. Brt.	Bn	
2	11 30 4	348.158	11 30 55	126.82	4, 4	3	367p. Brt.	Bn	
Dec. 5	11 10 49	128.193	11 11 56	180.48	4, 4	2–3	367p. Brt.	Bn	
5	11 35 29	128.368	11 37 20	179.96	4, 4	2–3	367p. Brt.	Bn	Brt. moonlight.
7	8 1 9	124.508	8 1 58	119.82	4, 4	2	495p. Brt.	Bn	
7	8 23 3	124.565	8 24 3	119.31	4, 4	2	495p. Brt.	Bn	
8	7 21 12	130.694	7 21 59	88.56	4, 4	2	495p. Brt.	Bn	
8	7 40 27	130.721	7 41 7	88.42	4, 4	2	495p. Brt.	Bn	
11	8 48 24	143.745	8 49 14	90.55	4, 4	2	367p. Brt.	Bn	Stopped by haze.
1912 Jan. 10	9 41 30	11.883	9 48 6	250.63	4, 4	3–4	367p. Brt.	Bn	
10	9 43 47	11.494	9 43 14	249.93	4, 4	3–4	367p. Brt.	Bn	

Titan–Japetus

Date	W.M.T.	Δα	Δδ	Comp.	Seeing	Power and Illum.	Obs.	Remarks
	h m s	s	″					
1911 Sept. 30	15 11 30	+46.209	+ 17.85	t30, 10	3	367, Red	Bn	
Oct. 4	12 32 2	+72.771	+ 29.77	t24, 8	3–4	367, Red	Bn	Star observed for *Japetus?*
18	14 20 16	+39.483	+271.60	t30, 10	2	367, Red	Bn	[*Japetus* v. ft. Clouded.
Nov. 11	9 53 22	−47.739	− 93.76	t18, 6	2–3	367, Brt.	Bn	Interrupted by haze and
19	13 3 56	−27.807	−118.09	t30, 10	3–4	367, Brt.	Bn	Haze. [clouds. Clouded.
21	9 11 19	−31.871	−113.38	t30, 10	2	367, Brt.	Bn	
22	12 0 31	−39.310	−125.80	t30, 10	2	367, Brt.	Bn	*Japetus* faint at times. In-
26	11 15 48	−40.954	−231.08	t30, 10	2	367, Brt.	Bn	[terrupted by haze.
Dec. 18	8 12 42	+45.530	+ 6.61	t30, 10	2–3	367, Brt.	Bn	*Japetus* faint.

Comp.: t = transits. Seeing: 1 = excellent, 2 = good, 3 = fair, 4 = poor. Power and Illum.: b = occulting bar over planet, p = prism, Red = red wires, Brt. = bright field. Obs.: H = HALL, Bn = BURTON.

Clark II micrometer was used for all observations.

Value of one revolution = $9''.9329 + 0''.0000\,525\,(t - 50°F.) + 0''.0255\,(1^{in}.280 - \text{focal scale})$.

U. S. Observatory, Washington, D. C.,
1922, March 27.

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THE INTERPRETATION OF APPARENT CHANGES IN MEAN LATITUDE,

AT THE INTERNATIONAL LATITUDE STATIONS.

By WALTER D. LAMBERT.

I

In a paper presented by the writer at the Swarthmore meeting of the American Astronomical Society,[1] December 29, 1921, attention was called to the fact that the *mean* latitudes of the international latitude stations, that is, the latitudes cleared of the effects of the annual and of the 14-month terms, showed, during the years 1900 to 1917 inclusive, a general tendency toward a progressive increase. These changes were explained as due in part to cumulative errors in the declinations used, errors due presumbaly to imperfections in the proper-motions, and in part to a progressive displacement of the North Pole toward the American continent. In a paper published in this *Journal*[2] PROF. SCHLESINGER concurs in the idea that the apparent changes in latitude are due to erroneous proper-motions and finds that a change from the Auwers-Cohn system of the International Latitude Service to the LEWIS BOSS system will, in the main, largely reduce these changes even without a motion of the pole. The chief exception is the station Mizusawa; this station, after the change to the Boss system, shows a decrease of 0″.0079 annually. This decrease PROF. SCHLESINGER explains by a southward "proper-motion" of the ground on which the station rests and explains the movement as presumably due to stresses in the earth's crust in accordance with the elastic-rebound theory of earthquakes. The 0″.0079 is equivalent to about 9½ inches or 24 centimeters.

The purpose of the present paper is to present, in more detail than would have been desirable at the Swarthmore meeting, the methods by which the rates of change of latitude were derived, to give a discussion of these rates, suggested in part by PROF. SCHLESINGER's paper, and to touch briefly on the elastic-rebound theory of earthquakes.

[1]*Journal of the Washington Academy of Sciences*, Vol. XII, p. 28, 1921.

[2]Vol. XXXIV, p. 42, 1922.

The only periodic terms used in reducing the observed latitudes to their mean values were the annual term and the 14-month term. The exact period of the latter was taken as 432.5 mean solar days, a mean result between the 432.2 days found by DYSON and the 432.8 days found by WANACH. If the mean latitude is taken over the period of a year, the effect of annual or semi-annual periodic terms disappears from the mean. To remove the effects of the 14-month term, harmonic analyses were made for each station independently and without reference to any motion of the pole. The amplitudes and epochs thus deduced were used to eliminate the effect of the 14-month term from the mean latitude corresponding to any calendar year at the station. Full details are given in special publication No. 80 of the U. S. Coast and Geodetic Survey, now in press. The results only are given in Table 1. The results for TSCHARDJUI are all reduced to the original station. The data for the reduction are given in Vol. V, p. 2, of the *Resultate des Internationalen Breitendienstes* and a map of the vicinity is given in Vol. I.

A similar table could be prepared in which would be given the mean latitudes by periods of 432.5 days, the effect of the annual terms being removed by the necessary harmonic analyses of the observed latitudes and by the subsequent computation. Such a table is given in special publication No. 80, but to save space it is omitted here. The general trends of the latitudes are very similar to those discernible in Table 1, as will appear from Table 2 below.

To evaluate the rates of change disclosed in Table 1, a set of observation equations may be assumed for each station in the form

$$x + yt = \Delta\phi. \qquad (1)$$

In this form of representation, t is the time in years, reckoned from a convenient epoch, $\Delta\phi$ is the tabular

TABLE 1

SECONDS OF MEAN LATITUDES BY CALENDAR YEARS

(Effect of 14-month term removed by computation)

Calendar Year	Mizusawa	Tschardjui	Carloforte	Gaithersburg	Cincinnati	Ukiah
	″	″	″	″	″	″
1900	3.612	10.686	8.921	13.139	19.343	12.088
1901	.623	.688	.995	.199	.299	.053
1902	.575	.635	.936	.233	.389	.059
1903	.586	.676	.922	.246	.411	.104
1904	.597	.659	.956	.197	.420	.118
1905	.581	.611	.963	.216	.290	.125
1906	.591	.536	.930	.234	.335	.112
1907	.580	.595	.913	.239	.304	.092
1908	.592	.676	.921	.257	.370	.071
1909	.589	.686	.936	.255	.351	.115
1910	.597	.706	.959	.259	.372	.136
1911	.555	.763	.956	.281	.415	.162
1912	.587	.731	8.970	.314	.431	.178
1913	.602	.791	9.000	.304	.423	.157
1914	.611	10.856	9.000	13.343	.490	.216
1915	.580		8.995		19.530	.256
1916	.590		9.021			.240
1917	3.615		9.063			12.236

number in Table 1 for the given year and station, diminished by a convenient arbitrary constant if desired, x is the adjusted value of $\Delta\phi$ for the assumed epoch, and y is the adjusted annual rate, assumed to be uniform, at which the latitude of the station is changing.

It appears from an inspection of Table 1 that the rate of change of latitude tends to be more rapid during the latter part of the period treated. To represent this fact there were used as alternatives to equations in the form (1) equations of the form

$$x + yt_1 + zt_2 = \Delta\phi. \qquad (2)$$

In this equation, t_1 is the time before 1912.00. After this epoch t_1 is taken as zero; similarly t_2 is the time after 1912.00, being zero before that epoch. The quantities y and z are the adjusted rates of change before and after 1912.00 respectively. The symbol $\Delta\phi$ has the same meaning as in (1), and in (2) x is the adjusted value of $\Delta\phi$ for 1912.00. The date 1912.00 was chosen partly on account of the appearance of the data in Table 1 when plotted, partly because this date is the time of transition from the definitive values of the latitudes as worked up in Vols. III and V of the *Resultate des Internationalen Breitendienstes* to the provisional values given in the *Nachrichten*.[3] Expressed graphically the process just outlined is equivalent to representing the mean latitudes by two different straight lines before and after 1912.00; the two lines meet on the ordinate corresponding to 1912.00.

It was found that the values of z in equation (2) deduced from stations for which the observations extend through 1917 differed systematically according as the years used were cut off with 1914 or extended to 1917. The values of y were practically unaffected. A similar systematic difference appears in the values of y in equation (1) and depends on the length of time covered by the data. The longer the period the larger y is found to be. The rates quoted in PROF. SCHLESINGER's paper are values of y from (1) covering the whole period of observation at the station in question. Since these periods are of different lengths for different stations, these values of y are not strictly comparable with one another. In order then to make results at all stations more nearly comparable, we shall confine ourselves at first to observations not later than 1914; in this case all six stations may be used.

Table 2 gives the values of y and z as found by least-square adjustments based on observation equations of the forms (1) and (2). The heading "1900–1914" in

[3] *Astronomische Nachrichten*, Vol. CXCVIII; No. 4749, 1914. Vol. CCI; No. 4802, 1915. Vol. CCIII; No. 4858, 1916. Vol. CCV, No. 4908, 1917. Vol. CCVIII; No. 4969, 1918.

TABLE 2

MEAN ANNUAL RATES OF CHANGE OF LATITUDE WITH PROBABLE ERRORS

(Unit 0″.0001 per annum. Conversion factor *tabular units to centimeters* is 0″.308)

Station	Longitude	1900–1911 By Calendar Years	1900–1911 By 14-month Periods	1900–1914 By Calendar Years	1900–1914 By 14-month Periods
	° ′				
Mizusawa	141 08 E	−25 ± 7	−27 ± 8	− 6 ± 7	− 11 ± 7
Tschardjui	63 29 E	+42 ±29	+30 ±32	+109 ±26	+112 ±28
Carloforte	8 19 E	+ 3 ±12	− 1 ±16	+ 30 ±11	+ 25 ±12
Gaithersburg	77 12 W	+90 ±11	+83 ±14	+103 ± 9	+103 ±10
Cincinnati	84 25 W	+31 ±23	+26 ±21	+ 72 ±20	+ 81 ±19
Ukiah	123 13 W	+63 ±13	+72 ±14	+ 84 ±11	+ 80 ±10

Table 2 indicates that form (1) was used to obtain an average rate for this period. The heading "1900–1911" indicates that equation (2) was used; the figures under this heading are values of y and therefore apply only to the period indicated, although the data used extended through 1914. The values of z applying to the years 1912–1914 are too poorly determined to be particularly significant and are not given.

Table 2 contains the rates deduced from Table 1 and also the rates from the omitted table of mean latitudes by 14-month periods. In working up the latter the date for the change from one straight line to another was not precisely 1912.0 nor precisely the same for all stations, but the difference is unimportant. The agreement between these two sets of rates is satisfactory. The probable errors are also shown in the usual way.

II

It is rates of this character and order of magnitude, although, as has been noted, not always these identical rates, for which Prof. Schlesinger would account by subtracting 87 of the units here used, or $0''.0087$ per annum, a figure deduced from a comparison of stars common to the two declination systems. This correction reduces the rates at four of the stations to small amounts, but leaves Mizusawa and, to a less extent, Carloforte standing out from the rest by amounts so large in comparison with the probable errors of the rates themselves as to necessitate some further hypothesis, such as that of a "proper-motion" of the ground at the stations in question.

Another possible hypothesis is that previously made by the writer, namely, a shifting of the North Pole towards the American continent combined with a cumulative correction to the declinations, both elements to be determined from the rates themselves. To formulate this hypothesis let u represent the annual displacement of the mean position of the North Pole towards the Equator along the meridian of Greenwich, and let v represent the corresponding annual displacement along the meridian of 90° West. By "mean position of the pole" is meant the position freed from the effects of periodic terms. Further let w represent the average correction to the annual proper-motion of the stars used, these being assumed to be identical at all stations, and let λ denote the west longitude of a station. Then we have for any station

$$u \cos \lambda + v \sin \lambda + w = \text{annual rate from Table 2.} \quad (3)$$

There are six observation equations like (3) to determine u, v, and w.

Apart from the *a priori* probability of a displacement of the pole, a question which will be touched on briefly hereafter, the plausibility of the hypothesis may be judged by the size of the residuals. To condense the work means were formed between the rates in the third and fourth columns of Table 2 and between those in the fifth and sixth columns. The two sets of means thus formed gave two sets of annual rates to be used in observation equations of form (3). These two sets of mean rates and the values of u, v and w deduced from them are shown in Tables 3A and 3B.

The question of weights must also be considered. One logical system of weighting would be to take weights in accordance with the theory of least squares, that is, inversely proportional to the probable errors of the rates in Table 2. Another method would be to give all stations equal weight. Both systems have been tried. For reasons that will appear, solutions were made in which Tschardjui was omitted, also solutions in which both Tschardjui and Mizusawa were omitted. In order to designate briefly the various possible combinations of omitted stations and methods of weighting, solutions in which all stations are included are numbered I, those in which Tschardjui is omitted II, and those in which both Tschardjui and Mizusawa are omitted are numbered III. The letter a signifies that weights were assigned approximately in the ratio of the inverse squares of the probable errors in Table 2, while b signifies that the weights of all stations were equal. In the columns under the residuals for solutions II and III the figures in italic type for Tschardjui and Mizusawa are the residuals computed from the adjusted values of u, v, and w, although the corresponding rates did not, in these instances, enter into the adjustment.

Before discussing the results in Tables 3A and 3B it is desirable to put down the results obtained by extending the discussion beyond 1914. Except for one year at Cincinnati there are only three stations left, Mizusawa, Carloforte and Ukiah, just enough to determine u, v and w; there can be no question of weights or of residuals. If observation equations of form (2) are applied to the observations at these three stations for the years 1900–1917 inclusive, the z's, though rather poorly determined, may have some value. The mean z's and the results from using them as the annual rate in equation (3) are given in Table 3C under the headings "1912–1917." Observation equations of form (1) were also applied to the three stations for the entire period 1900–1917; the y's deduced are mean rates of increase for this period. These y's, which were used as the rates of increase in equation (3), and the cor-

TABLE 3A

Polar Motion 1900–1911 with Probable Errors

(unit 0″.0001 per annum)

	All Stations		Tschardjui Omitted		Mizusawa and Tschardjui Omitted	
	Ia	Ib	IIa	IIb	IIIa	IIIb
u	+ 1.3 ± 11.1	+ 8.2 ± 18.7	**− 1.6** ± 10.3	− 2.6 ± 15.3	− 2.2 ± 29.9	− 15.7 ± 42.0
v	+ 57.3 ± 9.9	+ 32.6 ± 14.2	**+ 63.1** ± 9.0	+ 54.5 ± 14.3	+ 62.4 ± 36.6	+ 38.4 ± 48.6
w	+ 16.4 ± 7.4	+ 25.4 ± 11.4	**+ 12.4** ± 6.7	+ 9.2 ± 11.1	+ 13.0 ± 9.5	+ 23.2 ± 11.5

TABLE 3A — (*Continued*)

Residuals. Table 2 *minus* adjusted value

Station	Rate from Table 2	Ia	Ib	IIa	IIb	IIIa	IIIb
Mizusawa	−26	− 3.0	−21.6	0.0	− 3.6	*− 1.6*	*−37.4*
Tschardjui	+36	+69.0	+36.1	*+80.8*	*+76.7*	*+79.7*	*+54.2*
Carloforte	+ 1	−11.1	−27.8	− 0.7	− 0.2	− 0.8	− 1.1
Gaithersburg	+86	+12.7	+27.0	+12.4	+24.2	+12.6	+28.9
Cincinnati	+28	−45.6	−30.6	−47.1	−35.2	−46.9	−31.9
Ukiah	+68	+ 6.0	+19.8	+ 1.9	+11.8	+ 1.6	+ 4.1

TABLE 3B

Polar Motion 1900–1914 with Probable Errors

(unit 0″.0001 per annum)

	All Stations		Tschardjui Omitted		Mizusawa and Tschardjui Omitted	
	Ia	Ib	IIa	IIb	IIIa	IIIb
u	+ 13.2 ± 13.2	+ 22.0 ± 24.2	**+ 4.6** ± 1.1	+ 4.2 ± 6.9	+ 9.3 ± 12.4	+ 2.4 ± 19.2
v	+ 53.0 ± 11.8	+ 21.9 ± 18.4	**+ 62.2** ± 1.0	+ 58.5 ± 6.5	+ 68.6 ± 15.5	+ 56.4 ± 22.2
w	+ 10.5 ± 8.8	+ 59.4 ± 14.8	**+ 31.1** ± 3.0	+ 32.4 ± 5.1	+ 29.0 ± 12.4	+ 34.3 ± 19.0

TABLE 3B — (*Continued*)

Residuals. Table 2 *minus* Adjusted Value

Station	Rate from Table 2	Ia	Ib	IIa	IIb	IIIa	IIIb
Mizusawa	− 8	− 5.0	−36.5	+ 0.5	− 0.4	*+ 13.4*	*− 5.1*
Tschardjui	+110	+111.4	+60.3	*+129.5*	*+128.1*	*+138.3*	*+125.1*
Carloforte	+ 28	− 17.8	−50.0	− 1.6	− 0.1	− 0.2	− 0.5
Gaithersburg	+103	+ 7.9	+17.4	+ 7.2	+ 12.6	+ 5.0	+ 13.2
Cincinnati	+ 76	− 18.6	− 7.3	− 20.5	− 15.5	− 22.2	− 11.6
Ukiah	+ 82	+ 4.4	+16.4	− 1.7	+ 2.9	+ 0.7	+ 4.8

responding values of *u*, *v* and *w* are given in Table 3C under the headings "1900–1917."

A comparison of solution Ib in either Table 3A or 3B with any of the other solutions shows at once the

TABLE 3C
EXTENSION OF POLAR MOTION TO 1917
(unit 0″.0001 per annum)

Station	Annual Rate 1912–1917 z	Annual Rate 1900–1917 y		1912–1917	1900–1917
Mizusawa	+ 96	+ 8	u	+ 31.7	+ 7.5
Carloforte	+182	+ 53	v	+ 6.20	+65.8
Ukiah	+194	+106	w	+159.6	+55.1

great disturbing effect of Tschardjui and strongly suggests the presence of some abnormal influence. As will be seen, however, from Table 1 this disturbing influence does not make itself felt until near the time when it became necessary to move the Tschardjui station (July, 1909). For the first seven or eight years the mean latitude shows a tendency to decrease at a rate quite consistent (within limits indicated by probable errors) with the rate computed from any of the solutions of Table 3A except Ib or perhaps IIIb. The reason for a change from a decrease to an increase, apart from the large probable errors always found here, might have been either: (1) a change in refraction due to changed atmospheric conditions as the Amu Darya shifted its course toward the station from its original channel some three kilometers away; or (2) a movement toward the approaching river of the ground on which the observatory stood. This movement of the ground would not be of the character implied in the elastic-rebound theory of earthquakes.[4] The original station was on the south bank, so a movement of this sort would explain the rather sudden increase noted in 1908 and 1909 and furthermore would affect the computed reduction from the new position to the old (there was no period of simultaneous observation at the two stations) in such a way as to make the latitudes after July, 1909, as reduced to the old station, always too large. The new station was established on the north side of the main channel, but not on the mainland, if the map given in Vol. I of the *Resultate des Internationalen Breitendienstes* still retains its validity for this particular region in spite of the great changes near the old station further down stream. The new station was apparently on one of the marshy islands in the river. The possibility of a still further earth movement is thus indicated: changes in the position of the main or secondary channels might also produce changes in the refraction. For the last few years at Tschardjui the rate of increase is about 600 tabular units, or several times as large as the largest deduced rate of increase combined with the largest "proper-motion" of the ground so far suggested by any one for Ukiah, Mizusawa or Carloforte. This seems to indicate something very abnormal.

For these reasons and because of the large probable error in the latitudes and the discordances shown in Tables 3A and 3B, it seems desirable to the writer to reject Tschardjui entirely. In passing it might be noted that solution Ia agrees well with WANACH's[5] determination of the motion of the pole; this latter applies to the same years and, with an unimportant exception, is, like solution Ib, based on equal weights for all stations.

When Tschardjui is rejected the question of weights loses much of its importance, but solutions IIa of Tables 3A and 3B and the solution for 1912–1917 in Table 3C are in such good agreement with one another that they have been adopted as the basis for a definitive statement regarding the motion of the mean pole for the years 1900–1917.

The larger value of u in Table 3C, solution for 1912–1917, interpreted in terms of the position of the pole, is seen to be essentially consistent, when the period covered is considered, with the change in the sign of u in solution IIa of Tables 3A and 3B. The mean North Pole may be conceived as moving with a velocity of 0″.0062 annually, the resultant motion for the years 1900–1911 being along the meridian of 91° W. From this time on the motion becomes a little more rapid and swings a little more to the east, along the meridian of 63° W., as deduced from Table 3C, so that the resultant displacement from the mean position of 1900.0 is in the direction of 85° W. at the end of 1914 and of 81° W. at the end of 1917. This final position agrees essentially with that deduced from the result for 1900–1917 in Table 3C: the coördinates of the mean pole[6] in 1918.0 referred to the mean pole of 1900.0 as origin would thus be $x = +0''.017$, $y = +0''.113$ by the former combination of solutions and $x = +0''.011$, $y = +0''.118$ by Table 3C for 1900–1917. For the period 1900–1911 the correction to the mean proper-motion of the stars used is seen to be small, namely, 0″.0012, these years being based on the definitive results of the *Resultate*. From 1912.0 on, the correction to the average proper-motion increases

[4]The immediate vicinity seems to be quite free from earthquakes, though there is a somewhat disturbed region to the east. See F. de Montessus de Ballore: Les tremblements de terre, géographie séismologique, p. 216–18.

[5]B. WANACH in *Resultate des Internationalen Breitendienstes*, Vol. V, p. 219

[6]These x's and y's are of course different from the x and y previously used.

rapidly, being 0″.0460 from Table 3C. This with the small correction from 1900 to 1911 gives about the same average accumulated correction for the entire period 1900–1917 as would be derived from Table 3C for 1900–1917.

As Prof. Schlesinger states, the argument for a polar motion rather than a simple correction to the proper-motion (rather larger than those here derived) derives much of its strength from the rate of change at Mizusawa. Solutions III, however, show that even with Mizusawa omitted the polar motion comes out about the same as before, although the new solution is much weaker. If there were in fact no displacement of the pole, the adjustment should bring this out by making u and v nearly zero, when Mizusawa is omitted. The probable errors of u and v are of the same order of magnitude as the quantities themselves, but it is noteworthy that in spite of the weakness of the determination, the actual values of u and v are not much affected. The probable errors in these adjustments where the number of equations is so little greater than the number of unknowns are not necessarily particularly significant. An examination shows, however, that Cincinnati is the principal contributor to the probable error. This station appears to be affected during the earlier years by some error, presumably accidental, which makes its rate of increase from 1900 to 1911 less than that of Gaithersburg or Ukiah. In the longer period 1900 to 1914 this error has less effect, as is seen by the decreased residuals and probable errors. When 1915 is included the mean annual rate from 1900 to 1915 becomes +99 tabular units and it looks as if the discussion of a still longer period would have brought Cincinnati into substantial agreement with its neighbors.

III

The consideration of the relative probabilities *a priori* of a progressive displacement of the pole and of a "proper-motion" of the ground at certain observatories amounting to some 20 centimeters or more a year might logically precede the examination of the observational evidence in favor of one or the other hypothesis. The two hypotheses are, however, so different as to be hardly comparable in our present ignorance of essential data.

The idea of a displacement of the pole may have lost favor to a certain extent because of the extravagances of the Reibisch-Simroth "pendulation theory" of polar motion, with its hypothesis of large periodic oscillations of the pole in enormously long periods. A certain amount of secular displacement of the pole is possible enough, if only there be granted a sufficient amount of uplift or subsidence of the *Earth's* crust or other rearrangements of the matter composing the crust or the interior. The difficulty is in accepting any such rearrangements on a scale sufficient to make the displacements of the pole play any controlling part in the climatic changes recorded in geologic history.[7]

There is evidence of a sort that a shifting of the pole of the same general character as is here deduced may have taken place during the nineteenth century. Hall and Helmert[8] give data showing apparent secular decreases in European latitudes during various periods in the nineteenth century. As a counterpart to these, data compiled by Schott[9] show apparent increases at stations in the United States where observations were repeated after a lapse of time. There are, however, so many sources of error that these results should be accepted with considerable caution, but it seems very improbable that such consistency in the sign of the changes can be due entirely to accidental error.

As evidence on the other side, namely, that the displacement of the pole now under consideration may not be secular or progressive in character, there are the following mean annual latitudes of Ukiah based on data furnished by Dr. H. G. van de Sande Bakhuyzen, Permanent Secretary of the Reduced Geodetic Association, to whom the Ukiah observations were sent. These mean latitudes form, therefore, apart from a possible uncertainty in the treatment of the declinations, a continuation of Table 2.

Calendar Year	Seconds of Mean Latitude, Ukiah
1918	12″.222
1919	12 .185
1920	12 .138

It would be safer to defer extended discussion of these figures until corresponding data for Mizusawa and Carloforte become available, but, taken at their face value, they appear to indicate a rapid swinging of the North Pole away from the American continent.

[7]See G. H. Darwin: On the Influence of Geological Changes on the *Earth's* Axis of Rotation. *Philosophical Transactions of the Royal Society of London*, Pt. I, Vol. CLXVII, p. 271 1877; reprinted in *Scientific Papers*, Vol. III, p. 1.

J. Barrell: The Status of the Hypothesis of Polar Wanderings. *Science*, Vol. XL, p. 333, 1914.

[8]A. Hall: *American Journal of Science and Arts*, Vol. XXIX, p. 223, 1885.

F. R. Helmert: *Höhere Geodäsie*, Vol. II, p. 145.

[9]C. A. Schott: The Transcontinental Triangulation, (Spec. Pub. No. 4, U. S. Coast and Geodetic Survey), p. 734.

The displacement of the pole toward the American continent during the years 1900–1917, if we accept that explanation, may have been mainly periodic in character and due to the combination of several periodic effects, each small in itself. A similar combination capable of simulating for a while a progressive displacement may not recur for a long time. If the existence of such periodic terms should eventually be established, it is probable that the periods will be identical with some of the known or suspected meteorological and climatic cycles.

According to the elastic-rebound theory of earthquakes there occurs first a slow accumulation of *stress* in the *Earth's* crust with a corresponding accumulation of strain. When the stress gets beyond the point of rupture, there is an earthquake as the strain is suddenly relieved and the strained portion of the crust rebounds to or beyond its original unstrained position.

Almost our only quantitative knowledge of the amount and extent of the slowly accumulating strain and subsequent rebound comes from the California earthquake[10] of 1906, although there is some numerical evidence to the same general effect to be derived from an earthquake which occurred in Sumatra[11] in 1892.

There is qualitative evidence that other earthquakes resembled these. We are therefore almost obliged to regard the California earthquake as typical of earthquakes of the stronger sort, but there is no strong reason for supposing that we make a serious error in so doing.

The earthquake of 1906 may be thought of as consisting essentially of a shear along an old fault line, the San Andreas fault, which has been traced some 600 miles in the general direction of the coast from the Colorado Desert on the south to Humboldt County on the north. The displacements of 1906 seem, however, not to have affected the southern part of the fault and to have been greatest along Tomales Bay (north of San Francisco) which itself follows the trace of the fault. There the maximum sudden relative displacement along the fault at the time of the quake was about 6 meters. These displacements are made evident by the offsetting of roads, fences, etc., that crossed the fault. Similar phenomena have been noted as a result of earthquakes elsewhere, but it is only in the case of California that, from surveys made both before and after the earthquake, we are able to get a good idea of how rapidly these displacements diminish as the distance from the fault increases.

Hayford and Baldwin found that on the northeast or continental side of the fault no displacement was large enough to be detected with certainty at a greater distance than 7 kilometers from the fault. A possible exception is Sonoma mountain, 34 kilometers from the fault. It seems more logical, however, to connect the displacement of Sonoma mountain with the earthquake of 1868, which appears to have been a movement along the Haywards fault, a fault which is approximately parallel to the San Andreas fault in the region of San Francisco Bay but across the bay from it.

On the southwest or seaward side of the San Andreas fault the displacements of 1906 died out more slowly than on the continental side, being still perceptible at the Farallon lighthouse some 37 kilometers from the fault. The displacement of this point is fairly well determined, though not so well as that of many other points. The displacements on the seaward side suggest also that the small strip of land between the fault and the sea had moved seaward by a small amount.

This sudden release of strain displacements varying from 6 meters down to zero was prepared for by a gradual creep in the opposite direction extending over many years. Prof. Reid[12] estimates this time as perhaps 100 years, a figure which he finds in general agreement with earthquake records for the Straits of Messina. Such a length of time would indicate rates of creep in substantial agreement with those found by Prof. Lawson, which are some 4 or 5 centimeters a year for points only a few kilometers from the fault.

This rate of 4 or 5 centimeters a year is to be contrasted with the 20 centimeters or more a year required by Prof. Lawson's interpretation of the latitudes at Ukiah or by Prof. Schlesinger's interpretation of the latitudes at Mizusawa. As a further evidence of the rate at which a creep of the surface may take place, we have the computations of Schmidt.[13] These show a secular creep of the crust during perhaps 75 years at the rate of something like one or two centi-

[10] J. F. Hayford and A. L. Baldwin: The Earth Movements in the California Earthquake of 1906. *U. S. Coast and Geodetic Survey Annual Report for 1907*, Appendix 3.

C. R. Duvall and A. L. Baldwin: Triangulation in California, Part II. *U. S. Coast and Geodetic Survey Annual Report for 1910*, Appendix 5.

H. F. Reid: The Elastic Rebound Theory of Earthquakes. *University of California Publications*, Bulletin of the Department of Geology, Vol. VI, No. 19, 1911.

A. C. Lawson: The Mobility of the Coast Ranges of California, an Exploitation of the Elastic Rebound Theory. *University of California Publications*, Bulletin of the Department of Geology, Vol. XII, No. 7, 1921.

[11] H. F. Reid: Sudden Earth Movements in Sumatra in 1892. *Bulletin of the Seismological Society of America*, Vol. III, p. 72, 1913.

[12] *Report of the State Earthquake Investigation Commission*, Vol. II, p. 32.

[13] M. Schmidt: Westwanderung von Dreieckspunkten infolge neuzeitlicher tektonischer Bewegungen im bayerischen Alpenvorland; in *Sitzungsberichte der mathematisch-physikalischen Klasse der Bayerischen Akademie der Wissenschaften zu München*, 1920, p. 297.

meters a year. The region (southern Bavaria) is on the edge of a region somewhat affected by earthquakes, namely, the Alps, as shown by the maps of Montessus de Ballore.[14] An earthquake takes place when the rock is strained to the point of rupture and with the hypothetical larger rate of 20 centimeters or more a year strong earthquakes would occur several times as frequently as they would with smaller rates like 4 or 5 centimeters.

Another element of difference between the observed displacements and those assumed by Prof. Schlesinger and Prof. Lawson is the distance of the latitude stations from the areas of disturbances. Ukiah is some six times as far from the San Andreas fault as the farthest post whose sudden displacement could be proved. Though it was badly shaken at the time of the earthquake, Ukiah seems to have suffered no change in position at the time, so far as shown by either the astronomic latitudes or the results of the triangulation. Mizusawa is described as being subject only to relatively light earthquakes which come in general from a source some 100 kilometers away toward the southeast.

When the rates of surface creep required by the interpretations of Schlesinger and Lawson are compared with the only rates of creep whose amount may fairly be considered as established, and when the distances to which the creep must extend are compared with the much smaller distances beyond which no creep has been detected by a survey, it is seen that the application of the elastic theory to explain the rates of change of latitude at Ukiah, Mizusawa or Carloforte requires an extension of that theory considerably beyond the established facts. It should be said, however, that the elastic-rebound theory does not necessarily require the entire movement of the ground to be elastic. There might conceivably be a horizontal displacement unaccompanied by much elastic stress, except near the fault along which the rebound is to occur.

It may prove, therefore, that large creeps of 20 centimeters or more a year exist. One purpose of the international latitude stations might well come to be a study of just such questions. But it seems pertinent to remark that if destructive earthquakes are caused by creeps of 4 or 5 centimeters a year extending over an area a few kilometers wide, then creeps of several times that amount extending over areas many times greater might be expected to lead to earthquakes more frequent and more devastating than usually occur.

For these reasons the writer prefers to reject the hypothesis of large Earth movements at Mizusawa, Ukiah or Carloforte as the dominating cause of rates of change of latitude standing out from those determined at other stations and to explain such difference by a motion of the pole combined with a cumulative correction to the declinations, an hypothesis which fits the observations well, except those of the later years at Tschardjui, for the rejection of which there seem to be adequate reasons. The adopted rates of displacement of the pole for the years 1900–1917 are shown by the solutions IIa of Tables 3A and 3B and by Table 3C, and have been already discussed. The cumulative correction to the declination (w) seems to be increasing with the time and no one correction such as that derived by Prof. Schlesinger seems to be applicable throughout. The change appears to be due to a change in star program, being conspicuously large chiefly in the provisional latitudes of the *Astronomische Nachrichten*. It seems desirable that the individual declinations and proper-motions used in the individual results should be revised in order to secure a homogeneous declination system.

U. S. Coast and Geodetic Survey, Department of Commerce,
April 10, 1922.

[14] F. de Montessus de Ballore: Les tremblements de terre, géographie séismologique, p. 282.

NOTICE

Supplementing the notice regarding subscriptions to the *Astronomical Journal* published in No. 790, we suggest that foreign subscribers desiring to subscribe through an agency should address Wheldon and Wesley, Ltd., 28 Essex Street, Strand, London, W. C. 2, England.

Benjamin Boss, *Editor*

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MEASURES OF 100 DOUBLE STARS MADE WITH THE 26-INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY,

By CHAS. P. OLIVIER.

The present paper forms a continuation of the series by the writer which have appeared from time to time since 1906. As in the other recent papers most of the stars measured are among those discovered during the past twenty years. Thus the present list contains 48 JONCKHEERE, 13 AITKEN, 13 OLIVIER, 8 ESPIN, 7 HUSSEY and 11 miscellaneous pairs, the latter being mostly binaries. As to distance 21 are less than 1″.01, 35 between 1″.01 and 2″.01, 32 between 2″.01 and 3″.01, and 12 wider than 3″.01. However many of the wider ones have faint companions, so they would be difficult in a small telescope.

The right ascensions and declinations of the stars are for 1920. When possible both designations and coördinates are taken from JONCKHEERE's "*Catalogue of Double Stars.*" In other cases BURNHAM's "*General Catalogue*" was used. When from the former the catalogue number is in brackets [ ], when from the latter unbracketed. The magnitudes are, however, in all cases the estimates made at the telescope while measuring. The same methods of observation, micrometer, magnifying powers, etc., have been used as formerly. Of the 13 OLIVIER doubles measured, OL. 86 to 93 inclusive are new and published with complete measures. In a table following are given the new doubles OL. 94 to 106 inclusive, which have not as yet been measured on more than one night.

The writer desires to call attention to his measures of 70 *Ophiuchi* from parallax plates, which appeared in Part 2 of Vol. III, *Publications of the Leander McCormick Observatory*. In the position angles, by error, the supplements of the angles were published, and hence each angle should be subtracted from 180° to get its true value.

University of Virginia,
1922, June 8.

Hu 508 231 9.0 — 10.7
R.A. $0^h 25^m 31^s$ Decl. +48° 48′

21.556	347.4	1.46
21.702	348.9	1.64
21.629	348.2	1.55

OL 86 9.7 — 12
R.A. $0^h 26^m 15^s$ Decl. +48° 54′

20.678	210.6	0.8 ±
21.702	208.3	0.7 ±
21.190	209.4	0.8 ±

E 1129 [71] 9.6 — 9.8
R.A. $0^h 26^m 30^s$ Decl. +48° 50′

21.566	82.2	1.11
21.702	78.8x	0.89
12.634	80.5	1.00

J 225 [190] 9.6 — 10.0
R.A. $1^h 14^m 08^s$ Decl. +15° 05′

16.955	210.0	2.81
21.902	208.0	2.77
19.428	209.0	2.79

J 930 [506] Δm 0.0
R.A. $3^h 16^m 56^s$ Decl. +18° 14′

21.810	121.0	3.70
21.997	119.8	3.47
21.904	120.4	3.58

J 932 [531] 9.5 — 10.7
R.A. $3^h 30^m 08^s$ Decl. +21° 10′

21.810	289.4	1.52
21.997	287.2	1.63
21.904	288.3	1.58

J 1084 [532] 9.2 — 10.8
R.A. $3^h 30^m 24^s$ Decl. +17° 27′

21.810	133.9	3.74
21.997	133.5	3.74
21.904	133.7	3.74

J 26 [537] Δm 0.0
R.A. $3^h 31^m 46^s$ Decl. +15° 0′

21.810	146.7	2.32
21.989	147.0	2.59
21.997	145.2	2.42
21.932	146.3	2.44

J 306 [595] 9.2 — 9.4
R.A. $3^h 53^m 09^s$ Decl. +21° 14′

21.810	87.5	2.17
21.989	85.9	2.21
21.900	86.7	2.19

Ho 1218 **[685]** Δm 0.8

R.A. $4^h\,31^m\,25^s$ Decl. $+15°\,21'$

21.810	75.2	1.53
21.989	71.0	1.64
21.900	71.6	1.58

No motion indicated.

J 323 **[793]** 7.5 — 9.0

R.A. $5^h\,05^m\,34^s$ Decl. $+10°\,48'$

21.810	163.1	3.25
21.915	162.4	3.37
21.862	162.8	3.31

J 15 **[802]** 9 — 11.8

R.A. $5^h\,07^m\,10^s$ Decl. $+8°\,53'$

21.810	212.0	2.40
21.915	211.2	2.63
21.862	211.6	2.52

J 1013 **[808]** 9.2 — 9.5

R.A. $5^h\,08^m\,38^s$ Decl. $+18°\,26'$

21.810	330.1	2.10
21.898	329.4	2.12
21.854	329.8	2.11

OΣ 87 9.7 — 9.8

R.A. $5^h\,08^m\,16^s$ Decl. $-3°\,40'$

21.940	299.8	2.00
21.989	300.9	2.05
21.964	300.4	2.02

J 18 **[820]** Δm 0.2

R.A. $5^h\,11^m\,21^s$ Decl. $+1°\,07'$

20.081	26.6	2.21
21.940	29.6	2.29
21.510	28.1	2.25

J 769 **[906]** 9.1 — 9.7

R.A. $5^h\,28^m\,28^s$ Decl. $+21°\,23'$

21.849	240.8	3.36
21.997	243.0	3.45
21.923	241.9	3.40

J 248 **[917]** Δm 0.2

R.A. $5^h\,36^m\,27^s$ Decl. $+18°\,36'$

21.849	25.8	3.53
22.093	28.2	3.62
21.971	27.0	3.58

J 1046 **[912]** Δm 0.0

R.A. $5^h\,35^m\,23^s$ Decl. $+20°\,30'$

21.849	106.7	2.82
22.093	105.8	2.94
21.971	106.2	2.88

J 656 **[1011]** Δm 1.0

R.A. $5^h\,48^m\,10^s$ Decl. $+11°\,23'$

21.849	105.9	3.82
22.093	106.2	3.97
21.971	106.0	3.90

J 1116 **[1014]** 8.5 — 8.7

R.A. $5^h\,49^m\,30^s$ Decl. $+6°\,24'$

21.810	268.0	2.23
21.849	269.0	2.21
21.830	268.5	2.22

J 407 **[1055]** 7.8 — 8.9

R.A. $5^h\,55^m\,55^s$ Decl. $+9°\,41'$

21.810	192.0	2.12
21.849	193.1	1.95
21.830	192.6	2.04

J 333 **[1067]** 8.8 — 10.2

R.A. $5^h\,57^m\,43^s$ Decl. $+12°\,10'$

21.810	295.7	2.37
21.849	295.8	2.23
21.830	295.8	2.30

J 309 **[1059]** 9.5 — 10.5

R.A. $5^h\,56^m\,48^s$ Decl. $+10°\,23'$

21.810	81.7	3.61
21.849	77.4	3.63
21.830	79.6	3.62

Identity not certain.

J 51 **[1077]** 8.6 — 9.0

R.A. $5^h\,59^m\,02^s$ Decl. $+8°\,12'$

21.810	117.8	1.41
21.940	119.0	1.41
21.875	118.4	1.41

Sirius **3596**

R.A. $6^h\,41^m\,36^s$ Decl. $-16°\,36'$

21.915	61.4	11.04
21.940	61.9	10.96
21.928	61.6	11.00

J 21 **[1165]** Δm 0.4

R.A. $6^h\,57^m\,55^s$ Decl. $+10°\,38'$

21.849	272.9	3.02
21.997	272.8	3.04
21.423	272.8	3.03

J 22 **[1171]** Δm 0.2

R.A. $6^h\,58^m\,35^s$ Decl. $+12°\,11'$

21.849	330.8	1.54
22.093	331.0	1.63
21.971	330.9	1.58

J 366 **[1562]** 8.7 — 9.6

R.A. $7^h\,19^m\,34^s$ Decl. $+12°\,41'$

21.810	138.4	1.98
21.849	140.9	1.84
21.830	139.6	1.91

J 1257 **[1569]** 10.4 — 10.5

R.A. $7^h\,20^m\,07^s$ Decl. $+12°\,16'$

21.810	31.4	1.95
22.093	27.2	1.93
21.952	29.3	1.94

A 1967 **[1602]** Δm 2

R.A. $7^h\,26^m\,57^s$ Decl. $-1°\,59'$

19.971	357.2	1.34
20.168	356.2	1.42
20.070	356.7	1.38

OΣ 79 9.8 — 10.6

R.A. $7^h\,27^m$ Decl. $-1°\,59'$

20.081	204.2	2.08
20.163	207.4	1.90
20.122	205.8	1.99

Following A 1967.

J 731 **[1625]** Δm 0.4

R.A. $7^h\,32^m\,16^s$ Decl. $+3°\,05'$

20.113	112.6	2.84
21.915	113.4	2.64
21.014	112.8	2.74

J 45 **[1642]** 9.2 — 10.4

R.A. $7^h\,37^m\,15^s$ Decl. $+9°\,12'$

21.810	184.4	2.89
21.849	185.5	2.96
21.828	185.0	2.92

A 2741 [**1651**] 9.4 — 9.5

R.A. $7^{h}\ 38^{m}\ 24^{s}$ Decl. $-13°\ 09'$

19.971	219.1*x*	0.90
20.168	220.9	1.04
20.070	220.0	0.97

J 707 [**1663**] 9.8 — 10.1

R.A. $7^{h}\ 42^{m}\ 16$ Decl. $+11°\ 17'$

18.175	303.6	1.56
20.168	300.8	1.72
19.172	302.2	1.64

A 2570 [**2019**] Δm 0.0

R.A. $10^{h}\ 21^{m}\ 51^{s}$ Decl. $+3°\ 20'$

19.971	318.9	0.45
20.168	318.9	0.44
20.070	318.9	0.44

Motion in angle indicated.

A 2572 [**2060**] 9.1 — 9.6

R.A. $10^{h}\ 44^{m}\ 42^{s}$ Decl. $+1°\ 50'$

19.971	116.3	0.71
20.168	113.1	0.63
20.070	114.8	0.67

E 724 [**2118**] Δm 1.4

R.A. $11^{h}\ 50^{m}\ 04^{s}$ Decl. $+50°\ 59'$

21.223	224.7	2.64
22.107	229.0	2.49
21.665	226.8	2.56

E 1248 [**2172**] Δm 0.2

R.A. $12^{h}\ 07^{m}\ 15^{s}$ Decl. $+41°\ 47'$

21.223	71.2	1.93
22.107	74.0	1.81
21.665	72.6	1.87

J 749 [**2252**] Δm 0.6

R.A. $13^{h}\ 21^{m}\ 15^{s}$ Decl. $+15°\ 43'$

20.201	284.3	2.57
21.264	285.2	2.35
20.732	284.8	2.46

A 1611 [**2268**] Δm 0.0

R.A. $13^{h}\ 32^{m}\ 45^{s}$ Decl. $+7°\ 15'$

20.201	137.7	0.60
21.242	139.1	0.71
20.722	138.4	0.66

Fixed.

E 608 [**2270**] Δm 0.5

R.A. $13^{h}\ 34^{m}\ 38^{s}$ Decl. $+48°\ 33'$

21.223	276.9	2.87
22.107	280.5	2.65
21.665	278.7	2.76

Possible motion.

A 1794 [**2271**] Δm 0.0

R.A. $13^{h}\ 35^{m}\ 00^{s}$ Decl. $+12°\ 05'$

20.201	27.1	0.51
21.264	24.1	0.57
21.732	25.6	0.54

Fixed.

A 2064 [**2286**] Δm 1.8

R.A. $13^{h}\ 59^{m}\ 36^{s}$ Decl. $+18°\ 03'$

20.201	164.8	1.48
21.264	161.3	1.36
20.732	163.0	1.42

E 1156 [**2291**] Δm 0.1

R.A. $14^{h}\ 02^{m}\ 07^{s}$ Decl. $+45°\ 31'$

21.223	259.4	2.66
22.107	257.8	
22.202	256.9	2.32
21.844	258.0	2.49

A 2065 [**2295**] Δm 1.3

R.A. $14^{h}\ 04^{m}\ 31^{s}$ Decl. $+17°\ 06'$

20.201	340.0	1.79
22.381	334.6	1.62
22.392	341.7	1.61
21.325	338.8	1.67

A 2226 [**2322**] 9.2 — 9.2

R.A. $14^{h}\ 28^{m}\ 30^{s}$ Decl. $+3°\ 30'$

17.302	296.2	0.90
18.227	290.8	0.91
19.227	289.6	0.78
18.252	292.2	0.86

Fixed.

A 2071 [**2332**] Δm 0.8

R.A. $14^{h}\ 48^{m}\ 43^{s}$ Decl. $+18°\ 17'$

20.201	266.4	0.82
22.395	264.9	0.84
21.298	265.6	0.83

J 440 [**2335**]

R.A. $14^{h}\ 50^{m}\ 22$ Decl. $+0°\ 36'$

21.242	218.6	2.53
22.381	219.5	2.61
21.812	219.0	2.57

E 1252 [**2362**] Δm 0.4

R.A. $15^{h}\ 15^{m}\ 06^{s}$ Decl. $+46°\ 29'$

19.254	16.9	
20.110	18.5	1.70
22.202	14.5	1.57
20.522	16.6	1.64

J 444 [**2384**] 9 — 10.0

R.A. $15^{h}\ 37^{m}\ 14^{s}$ Decl. $-0°\ 33'$

21.242	317.6	2.80
22.381	319.3	2.74
21.812	318.4	2.77

OΣ 303 **7177** Δm 0.2

R.A. $15^{h}\ 57^{m}\ 10^{s}$ Decl. $+13°\ 30'$

22.312	156.1	1.04
22.351	152.4	0.88
22.332	154.2	0.94

Σ 2026 **7561** Δm 0.2

R.A. $16^{h}\ 12^{m}\ 01^{s}$ Decl. $+7°\ 35'$

22.312	63.6	0.62
22.351	65.7	0.65
22.332	64.6	0.64

Δ15 **7748** Δm 0.2

R.A. $16^{h}\ 41^{m}\ 27^{s}$. Decl. $+43°\ 37'$

22.312	221.4	0.41
22.351	216.1	0.53
22.332	218.9	0.47

Σ 2114 **7837** Δm 1

R.A. $16^{h}\ 58^{m}\ 08^{s}$ Decl. $+8°\ 33'$

22.312	168.4	1.19
22.351	166.7	1.18
22.332	167.6	1.18

J 1248 [**2198**] Δm 0.6

R.A. $17^{h}\ 19^{m}\ 18^{s}$ Decl. $+16°\ 32'$

21.502	204.8	3.17
22.381	204.0	3.02
21.942	204.4	3.10

A 2183 [2500] Δm 3±

R.A. $17^{h}\,19^{m}\,56^{s}$ Decl. $+16°\,59'$

21.502	127.7	1.01
22.395	127.0	0.93
21.948	127.4	0.97

β 46 7991 Δm 2±

R.A. $17^{h}\,19^{m}\,59^{s}$ Decl. $+13°\,29'$

22.356	206.0	1.96
22.395	206.3	1.87
22.376	206.2	1.92

Hu 179 8056 Δm 0.1

R.A. $17^{h}\,27^{m}\,55^{s}$ Decl. $+11°\,16'$

22.356	51.4	2.05
22.395	52.1	1.98
22.376	51.8	2.02

Oᴌ 88 9.2 — 10.2

R.A. $17^{h}\,32^{m}$ Decl. $+13°\,18'$

22.356	281.7	2.36
22.381	284.6	2.61
22.395	288.4	2.46
22.377	284.9	2.48

Hu 923 13385 Δm 0.0

R.A. $17^{h}\,32^{m}\,21^{s}$ Decl. $+49°\,16'$

14.458	102.4	0.90
22.395	98.9	0.93
18.426	100.6	0.92

β 1121 8086 Δm 0.1

R.A. $17^{h}\,33^{m}\,43^{s}$ Decl. $+12°\,31'$

22.356	231.8	0.58
22.395	231.3	0.64
22.376	231.6	0.61

E 636 [2523] 9.2 — 10

R.A. $17^{h}\,34^{m}\,05^{s}$ Decl. $+41°\,46'$

20.201	124.2	1.94
21.242	126.7	2.01
22.395	126.8	1.80
21.279	125.9	1.92

E 1257 A B [2527] 9.4 — 9.6

R.A. $17^{h}\,35^{m}\,56^{s}$ Decl. $+45°\,02'$

20.201	295.4	2.57
21.242	295.1	2.70
20.722	295.1	2.64

Change of 31° in 7 years.

Hu 1284 [2536]

R.A. $17^{h}\,39^{m}\,56^{s}$ Decl. $+12°\,59'$

19.260	72.9	0.97
20.571	67.8	1.03
19.916	70.4	1.00

Oᴌ 89 9.5 — 10

R.A. $17^{h}\,47^{m}\,34^{s}$ Decl. $+54°\,13'$

20.201	172.0	0.8±
22.395	168.2	0.71
21.298	170.1	0.71

J 94 [2598] Δm 0.2

R.A. $18^{h}\,03^{m}\,06^{s}$ Decl. $+13°\,57'$

21.540	311.4	3.49
22.351	311.5	3.15
22.356	310.9	3.23
22.082	311.3	3.29

Oᴌ 18 Δm 0.4

R.A. $18^{h}\,12^{m}\,25^{s}$ Decl. $-35°\,42'$

19.500	119.2	1.90
21.242	120.3	1.73
20.371	119.8	1.82

Apparently fixed.

J 95 [2637] Δm 0.3

R.A. $18^{h}\,24^{m}\,03^{s}$ Decl. $+7°\,06'$

21.540	123.3	2.13
21.557	123.9	2.00
21.548	123.6	2.06

J 1149 [2611]

R.A. $18^{h}\,27^{m}\,42^{s}$ Decl. $+7°\,28'$

21.540	200.0	2.51
21.557	199.9	2.63
21.548	200.0	2.57

J 463 [2651] Δm 0.1

R.A. $18^{h}\,30^{m}\,0^{s}$ Decl. $+22°\,57'$

21.546	219.7	1.56
22.354	219.7	1.43
22.356	224.2	1.43
22.084	221.2	1.47

J 799 [2662] 9.5 — 11

R.A. $18^{h}\,33^{m}\,31^{s}$ Decl. $+19°\,06'$

21.502	74.4	2.27
22.351	70.9	2.34
21.926	72.6	2.30

Oᴌ 11 9.4 — 9.7

R.A. $18^{h}\,34^{m}\,14^{s}$ Decl. $+39°\,07'$

22.312	338.1	0.89
22.351	338.5	1.14
22.332	338.3	1.02

J 1212 [2666]

R.A. $18^{h}\,34^{m}\,51^{s}$ Decl. $+8°\,17'$

21.502	204.9	1.81
21.546	204.6	1.95
21.524	204.8	1.88

Oᴌ 15 *B.D.* +40°, 3437

R.A. $18^{h}\,35^{m}\,07^{s}$ Decl. $+40°\,10'$

22.312	23.9	1.67
22.351	24.3	1.74
22.332	24.1	1.70

J 1266 [2668]

R.A. $18^{h}\,35^{m}\,16^{s}$ Decl. $+10°\,23'$

21.502	30.3	1.58
21.546	29.5	1.81
21.524	29.9	1.70

J 1213 [2677]

R.A. $18^{h}\,35^{m}\,50^{s}$ Decl. $+8°\,22'$

21.557	130.2	1.87
22.351	132.9*x*	1.72
21.954	131.6	1.80

A 2262 [2701] Δm 0.4

R.A. $18^{h}\,44^{m}\,32^{s}$ Decl. $+1°\,37'$

21.540	348.2	1.07
21.557	352.3	1.13
21.548	350.2	1.10

J 808 [2715] Δm 0.2

R.A. 18h 45m 13s Decl. +7° 26′

21.546	351.0	1.34
21.557	354.6	1.41
21.552	352.8	1.38

Σ 2402 8811

R.A. 18h 45m 58s Decl. +10° 35′

22.312	25.8	1.05
22.395	29.9	1.07
22.354	27.8	1.06

OL 90 10.2 — 10.8

R.A. 18h 58m 34s Decl. +10° 14′

20.571	88.7	1.21
20.590	85.0	1.18
20.580	86.8	1.20

J 812 [2801] 9.4 — 9.8

R.A. 19h 04m 01s Decl. +9° 20′

17.715	121.1	1.94
21.557	122.1	2.35
21.702	120.9	2.31
20.325	121.4	2.20

OL 91 10.2 — 10.5

R.A. 19h 05m 12s Decl. +12° 56′

20.571	2.2	0.70
20.590	2.4	0.70
20.580	2.3	0.70

Hu 334 9104 8.8 — 12

R.A. 19h 08m 18s Decl. +18° 01′

19.500	245.6	1.44
20.571	243.5	1.47
20.036	244.6	1.46

No motion indicated in 19 years.

J 1305 [2887] Δm 0.8

R.A. 19h 21m 24s Decl. +13° 36′

21.546	164.9	1.52
21.557	166.2	1.51
21.552	165.6	1.52

J 1306 [2889]

R.A. 19h 21m 57s Decl. +13° 39′

17.715	291.5	2.07
20.590	289.3	2.21
21.546	290.2	2.29
19.950	291.3	2.19

OL 82 9.8 — 12

R.A. 19h 27m 36s Decl. +18° 07′

19.500	212.5	1.22
20.571	242.4	1.20
20.036	212.4	1.21

OL 92 9.9 — 12

R.A. 19h 38m Decl. +12° 56′

20.571	176.8	2.62
20.590	175.6	2.42
20.580	176.2	2.52

OL 93 9.8 — 11.2

R.A. 19h 51m 28s Decl. +11° 41′

21.702	158.3	1.52
21.726	161.5	1.47
21.714	159.9	1.50

J 149 [2937] 9.8 — 11.0

R.A. 19h 29m 56s Decl. +18° 03′

17.781	121.0	. .
19.500	120.5	1.89
20.571	119.8	1.99
19.284	120.4	1.94

A 722 13513 8.8 — 8.9

R.A. 20h 08m 04s Decl. +11° 52′

19.500	164.9	2.12
20.590	165.0	2.41
21.702	164.5	2.29
22.395	164.2	2.14
21.047	164.6	2.32

J 604 [3201]

R.A. 20h 11m 18s Decl. +11° 28′

19.500	229.2	0.59
20.571	226.2	0.47
20.036	227.7	0.53

Σ 2673 10160 8 — 9

R.A. 20h 18m 59s Decl. +13° 04′

20.678	328.3	2.54
21.557	329.5	2.46
21.118	328.9	2.50

Hu 1198 13527

R.A. 20h 20m 38s Decl. +12° 45′

20.678	34.7	0.52
21.546	30.2	0.58
21.112	32.4	0.55

J 562 [3299] 9.2 — 10.1

R.A. 20h 27m 20s Decl. +12° 31′

20.678	143.1	2.03
21.546	142.2	2.10
21.112	142.6	2.06

J 1 [3317]

R.A. 20h 29m 05s Decl. +11° 28′

19.500	38.5	1.58
20.571	38.7	1.62
20.036	38.6	1.60

Fox 37 [3322] Δm 0.3

R.A. 20h 30m 14s Decl. +13° 09′

19.500	56.6	1.31
20.590	54.6	1.36
20.045	55.6	1.34

J 194 [3396]

R.A. 20h 45m 32s Decl. +11° 07′

21.702	209.5	0.67
21.718	211.9	0.83
21.710	210.7	0.75

Possible motion.

γ *Equulei* 10782

R.A. 21h 06m 26s Decl. +9° 49′

19.500	271.2	2.30
20.590	272.4	2.25
20.045	271.8	2.28

J 851 [3516] Δm 0.1

R.A. 21h 18m 54s Decl. +15° 13′

21.566	142.1	1.53
21.718	112.5	1.24
21.642	112.3	1.38

Star	R. A.	Decl.	P. A.	Δ	Magn.	Found
	h m s	° ′	°	″		
Oi 94	5 4 13	− 3 36	263	2.2	10 — 12	21.940
95	5 11 01	+ 1 03	202	0.8	9.2 — 9.5	21.940
96	6 25 07	+21 07	65	4.7	9.2 — 10	21.849 *B.D.* +21.1259
97	7 35 24	−10 12	229	2.1	9.8 — 12	20.168 Pre. A2683
98	11 20 17	+ 1 0	330	2.2	10 — 12	21.242
99	16 51	−17 53	128	2.6	9 — 13.5	21.264
100	17 09	−17 55	187	3.3	9.5 — 12	21.264
101	17 21	+ 2 24	314	3.1	10 — 10.6	20.483 Pre. A2243
102	17 17	−20 43	276	3.	10 — 12	21.264
103	18 03	−27 40	274	4.4	9.5 — 11	21.242
104	18 14	−18 06	213	3.	9.5 — 10.5	21.264
105	18 48	+15 0	146	2.7	10.8 — 11.8	21.726
106	19 43 11	+14 58	215	3.2	10 — 10.5	21.726

PHOTOGRAPHIC DETERMINATIONS OF THE PARALLAXES OF 60 STARS WITH THE THAW REFRACTOR.

By KEIVIN BURNS.

The mean number of plates used in these determinations is 19.0, and the mean number of comparison stars is 3.9. The mean probable error is ″.0069. Eight plates, more or less defective, were rejected after measurement. In three regions half the plates were measured by former members of the staff.

The column headed "A. O. α" gives the proper-motion of the parallax star in right ascension relative to the comparison stars. The preceding column gives the absolute motion in right ascension as measured by Boss or Porter. The column headed "P. E." gives first the probable error of the parallax, then the probable error of weight unity, both expressed in thousandths of a second of arc. The last column gives the sector opening in per cent, an opening of 1.00 per cent indicates a reduction of about five magnitudes. The very narrow sectors, 0.06 and 0.03, appear to reduce about 8 and 8.5 magnitudes respectively.

We are again indebted to Director Shapley and the staff of Harvard College Observatory, to Professor Porter and to Professor Boss for data concerning magnitude, spectral class and proper-motion. The computing was done by Miss Bertha Grier.

The numbers are in continuation of earlier series. The work will appear in detail in *Publications of the Allegheny Observatory*.

No.	Name	α 1900	δ 1900	DM No.	Vis. Mag. Class	Proper-Motion Catalog Total	Proper-Motion Catalog α	A. O. α	Relative Parallax and P. E.	Sector %
		h m	° ′	°		″	″	″	″	
533	*θ Cassiopeiae*	1 05.0	+54 37	+54 236	4.5 A5	0.231	+0.230	+0.220	+.003 ± 6; 22	0.3
534	33 *Arietis*	2 34.8	+26 38	+26 443	5.4 A2	81	+ 73	+ 69	− 7 6; 22	1.5
535	*ρ Tauri*	4 28.2	+14 38	+14 720	4.8 A5	.106	.103	+ .113	+ 20 6; 20	0.25
536	*Lal.* 10262	5 23.2	+12 28	+12 801	6.8 F8	.241	+ .111	+ 88	+ 36 6; 23	3.0
537	*Groom.* 1216	6 38.2	+41 20	+41 1528	7.8 G0	.253	+ .166	+ .144	+ 41 4; 15	5.0
538	*Radclf.* 1805	6 39.9	+55 49		6.3	.128	+ 67	+ 66	+ 28 7; 23	3.0
539	*Radclf.* 1806	6 39.9	+55 49		6.3	.128	+ 67	+ 68	+ 27 8; 27	3.0
	Mean. Σ 958			+55 1122	F5	. . .	. . .	. . . .	+ 28 5; —	. . .
540	*Lal.* 16169	8 19.5	− 0 49	− 0 1987	6.8 G0	.230	+ 81	+ .106	+ 38 6; 20	10.0
541	Σ 1311	9 01.7	+23 23	. .	7.4	. .	. . . . . .	− .155	+ 3 7; 23	6.0

No.	Name	α (1900)	δ (1900)	DM. No.	Vis. Mag. Class	Proper-Motion Catalog Total	Proper-Motion Catalog α	Proper-Motion A. O. α	Relative Parallax and P. E.		Sector °
		h m	° ′	°		″	″	″	″		
542	Σ 1311	9 01.7	+23 23	+23 2048	6.7	0.159	−0.159	−0.145	−.012	±6;19	6.0
	Mean				6.3 F5		..	....	− 6	5;—	..
543	λ *Leonis* ...	9 26.0	+23 25	+23 2107	4.5 K5	53	− 20	− 5	+ 14	5;20	0.8
544	*g*22 *Leonis* ..	9 46.2	+24 52	+25 2169	5.3 A2	.192	+ 17	+ 27	+ 34	6;24	0.5
545	ν *Ursa Maj.*	11 13.1	+33 38	+33 2098	3.7 K0	26	− 20	− 12	+ 3	9;29	0.35
546	λ *Draconis* ..	11 25.5	+69 53	+70 665	4.1 Ma	43	− 37	− 44	+ 23	8;24	0.6
547	ν *Virginis* ..	11 40.7	+ 7 05	+ 7 2479	4.2 Ma	186	− 15	− 3	+ 3	10;23	0.5
548	Σ 1678*	12 40.4	+14 55	+15 2503	7.0	..	....	+ .109	+ 14	8;24	6.0
549	Σ 1678* ...	12 40.4	+14 55	+15 2504	6.8 A0	..		− 23	± 0	10;31	6.0
550	Σ 1788	13 49.7	− 7 34	− 7 3728	6.2 F8	.161	− .161	− .123	+ 17	7;19	2.0
551	β 1270 ..	13 58.7	+ 8 58	+ 9 2812	7.8 F5		....	+ 71	+ 43	7;24	10.0
552	β 1085 ...	14 53.7	− 4 35	− 4 3783	6.0 F5	.384	− .369	− .338	+ 6	5;17	1.2
553	W_1 583 .	15 33.2	+40 35	+40 2886	7.0 F8	.389	+ .139	+ .131	+ 14	5;16	2.5
554	*L Bo* 2294 .	15 43.1	+ 1 53	+ 2 3004	7.9 G5	.249	− .192	− .174	+ 31	8;24	3.5
555	ξ² *Scorpii* .	15 58.9	−11 06	−10 4237	4.8 F8	77	− 72	− 73	+ 41	5;16	4.0
556	φ *Herculis* ..	16 05.6	+45 12	+45 2376	4.3 B9p	30	− 18	− 24	+ 8	6;20	0.5
557	49 *Serpentis*	16 08.6	+13 48	.. ..	6.9	.	..	+ .217	+ 31	6;18	1.0
558	49 *Serpentis*	16 08.6	+13 48	..	6.7	.	. .	+ .184	+ 48	6;17	1.0
	Mean, Σ 2021	..		+13 3091	6.8 K0	.459	+ .171	.	+ 41	4;—	..
559	η *Draconis* .	16 22.6	+61 44	+61 1591	2.9 G5	62	− 15	− 43	+ 48	5;18	0.06
560	W_1 906	16 50.1	− 8 09	− 8 4352	9.2 K5p	1.234	− .858	− .849	+.162	9;27	35.0
561	*e Herculis* .	17 04.5	+36 01	+36 2827	5.4 A5	25	− 15	− 19	+ 10	8;26	0.4
562	*Groom.* 2433	17 15.3	+60 47	+60 1743	var K0	44	− 40	− 47	− 2	5;47	2.0
563	*Lal.* 32025	17 23.0	+73 06	+73 767	8.3 K0	.22–	+ 52	+ 62	+ 20	8;25	10.0
564	*Lal.* 31842	17 23.6	+26 52	+26 3023	8.0 G5	.289	− 96	− .111	+ 25	8;25	5.0
565	α *Ophiuchi*	17 30.3	+12 38	+12 3252	2.1 A5	.264	+ .121	+ .170	+ .39	8;28	0.03
566	*Lal.* 32769 .	17 43.0	+72 27	+72 803	8.4 K0	.324	− 99	− .117	+ 26	6;16	6.0
567	*Lal.* 32664 .	17 47.6	− 7 53	− 7 4517	7.6 G5	.246	− 71	− 67	+ 11	9;26	5.5
568	*Lal.* 33193 ..	18 00.0	+30 23	+30 3113	6.7 F5	.290	− 78	− 33	+ 22	5;16	2.5
569	40 *Draconis*	18 07.5	+79 59	+79 570	6.2 F5	.134	+ 57	+ 59	+ 18	7;22	2.0
570	41 *Draconis*	18 07.6	+79 59	+79 571	5.8 F5	.121	+ 50	+ 52	+ 6	7;22	2.0
	Mean, Σ 2308	..				.	...	...	+ 12	5;—	
571	36 *Draconis*	18 13.3	+64 22	+64 1252	5.0 F5	.351	+ .350	+ .356	+ 37	8;25	1.0
572	*Lal.* 34175 .	18 24.7	− 1 53	− 1 3509	8.2 K5	.252	+ .142	+ .178	+ 56	7;19	10.0
573	β 971	18 44.9	+49 20	+49 2871	7.2 F5	...	....	− 2	+ 18	6;18	4.0
574	β 648	18 53.3	+32 46	+32 3267	5.2 G0	.239	+ .177	+ .154	+ 55	7;24	1.0
575	17 *Lyræ* ..	19 03.6	+32 21	+32 3326	5.0 F	.125	+ .124	+ .176	+ 4	6;18	1.2
576	*Groom.* 2789	19 09.5	+49 40	.. ..	6.8	.629	− .167	− .184	+ 39	4;13	3.0
577	*Dorpat* 2258	19 09.5	+49 40	.....	6.6	.651	− .184	− .209	+ 35	6;19	3.0
	Mean, Σ 2486	.....	......	+49 2959	K	....	.....	......	+ 37	3;—	....

*The components of Σ 1678 appear to be unrelated.

No.	Name	α 1900	δ 1900	DM. No.	Vis. Mag. Class	Proper-Motion Catalog Total	Proper-Motion Catalog α	Proper-Motion A. O. α	Relative Parallax and P. E.	Sector %
		h m	° ′	°		″	″	″	″	
578	*α 6 Vulpeculæ*	19 21.5	+24 28	+24 3759	4.6 Ma	0.165	−0.123	−0.133	+.014 ± 7;18	1.8
579	*8 Vulpeculæ*	19 21.8	+24 33	+24 3761	6.0 G5	9	− 7	+ 5	+ 2 6;17	1.8
580	*Pi* 183	19 30.9	− 0 07	− 0 3788	7.9 G5	.376	− 15	− 23	− 5 8;22	10.0
581	15 *Sagittæ*	19 59.6	+16 48	+16 4121	5.9 G	.576	− .401	− .409	+ 69 8;21	4.0
582	*θ Sagittæ*	20 05.5	+20 37	+20 4453	6.3 F	.112	+ 59	+ 76	+ 40 6;19	5.0
583	Σ 2671	20 15.9	+55 05	......	7.5	..	......	− 35	+ 25 9;23	1.5
584	Σ 2671	20 15.9	+55 05	......	6.0	21	− 4	− 18	− 4 7;20	1.5
	Mean			+54 2329	5.7 A		......	......	+ 7 6;—	...
585	39 *Cygni*	20 19.9	+31 52	+31 4062	4.6 K	45	+ 45	+ 53	+ 8 7;20	2.0
586	*Groom.* 3263	20 38.2	+60 09	+59 2272	6.0 F	.185	+ 7	+ 22	+ 13 6;17	1.5
587	1 *Equulei*	21 00.5	+ 5 34	+ 5 4697	6.0 F5	.169	− .100	− 92	+ 8 8;24	5.0
588	*Pulk.* 3131	21 23.3	+48 24	+48 3390	5.3 A	78	+ 72	+ 73	± 0 7;23	2.2
589	*Pegasi* 29	21 28.4	+20 16	....	8.0	....	......	+ 1	+ 5 8;20	8.0
590	*Pegasi* 29	21 28.1	+20 16	......	7.5	.	....	+ 1	+ 18 8;20	8.0
	Mean, Σ 2804			+20 4955	7.1 F5	..	......	......	+ 12 6;—	....
591	*Brad.* 3077	23 08.5	+56 37	+56 2966	5.6 K	2.103	+2.083	+2.070	+.137 6;19	3.0
592	*Brad.* 3094	23 15.0	+47 50	+47 4114	6.4 K	.208	+ .206	+ .193	− 7 7;22	10.0

Allegheny Observatory, June 14, 1922.

ELEMENTS OF (944), 1920 HZ,

By FRANK E. SEAGRAVE.

The following elements are based upon three normal places from ten observations, Dec. 1, 1920 to Mar. 3, 1921, at Algiers. In eccentricity the orbit resembles that of a comet. When at perihelion ($r = 1.9835$) it is only 0.4 unit beyond *Mars*, while at aphelion ($r = 9.1377$) it is nearly as far out as *Saturn*.

Elements

Epoch 1921, June 12.3498 G.M.T.

	° ′ ″		
M	355 59 18.97	Log e	8.844601
ω	56 29 17.79	Log a	0.756535
π	77 48 18.56	Log q	0.297445
Ω	21 19 0.77	Log aphelion	0.974686
i	43 5 15.28	μ	260″.138
		Period	4981^{d}.963

Constants

$$x = r(9.986178) \sin (105^\circ\ 54'\ 24''.14 + u)$$

$$y = r(9.685884) \sin (\ 43\ \ 25\ \ 34\ .27 + u)$$

$$z = r(9.958566) \sin (\ \ 9\ \ \ 9\ \ 22\ .79 + u)$$

Comparison with an observation made at Yerkes Observatory, 1922, Jan. 28.8784 G. M. T., gives for O—C, $\Delta\alpha = +1^{s}.56$, $\Delta\delta = -1'\ 46''.06$.

CONTENTS.

Editor, Benjamin Boss, Albany, N. Y. Associate Editors E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward.
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THE PARALLAXES OF SEVENTY-TWO STARS,

By JOHN A. MILLER and JOHN H. PITMAN.

With the Cooperation of Caroline H. Smedley and Margaret E. Powell.

The parallaxes of the following stars were determined by the methods described in Sproul Observatory Publications Nos. 4 and 5. Each of the above shared in securing the necessary photographs and in the measurement of them. The computations were performed by Miss Smedley and Miss Powell.

The average number of plates used in each region is 13 and the average probable error of a parallax is 0″.0087. The details of the determinations of the parallaxes of fifty of these stars will appear in Sproul Observatory Publication No. 6.

No.	*B.D.* Number	Name	R. A. (1900)	Declination (1900)	Magnitude	Spect.	Relative Parallax		No. of Plates	Coördinates
	°		h m	° ′			″	″		
1	+32.101	*π Andromedæ*	0 31.5	+33 10	4.44	B3	−0.008	±0.004	13	R. A.
2	+18.122	OΣ 20 = 66 *Piscium*	49.3	+18 39	5.76	A0	+ .009	.008	14	R. A.
3	+68.64	. . .	54.9	+68 49	6.67	B9	− .006	.004	16	R. A.
4	+63.137	*A.G. Hels.* 914	1 0.4	+63 24	8.5	K6	+ .083	.005	14	R. A.
5	+20.306	*β Arietis*	49.1	+20 19	2.72	A5	+ .037	.006	15	R. A.
6	+70.153	β 513 = 48 *Cassiopeiæ*	53.8	+70 25	4.61	A3	+ .031	.006	16	R. A.
7	+33.395	*δ Trianguli*	2 10.9	+33 46	5.07	G0	+ .089	.005	10	R. A.
8	+29.393	*A* 961	14.3	+29 21	8.5	F5	+ .017	.006	13	R. A.
9	+48.746	*θ Persei* = Σ 296	37.4	+48 48	4.22	F8	+ .073	.009	12	R. A.
10	+45.669	*A* 1281	44.9	+45 34	9.2	G5	+ .048	.010	12	R. A.
11	+20.484	*ε Arietis* = Σ 333	53.5	+20 56	5.25–5.55	A2	+ .013	.006	13	R. A.
12	+ 5.435	W 2^h 927	55.2	+ 5 36	8.2	G5	− .011	.008	13	R. A.
13	. . . . . .	Anonymous	3 8.6	+ 0 17	10.	. . .	+ .066	.015	12	Long.
14	+ 8.482	W 3^h, 113	9.4	+ 8 37	7.7	K0	+ .042	.011	13	R. A.
15	. . . . . .	Anonymous	27.7	+24 10	10.	.	+ .017	.008	11	R. A.
16	+23.473	7 *Tauri* = Σ 412	28.5	+24 8	5.92	A2	+ .006	.011	11	R. A.
17	+41.750	*Lal.* 6888 (Σ 443)	40.1	+41 12	8.6	K	+ .059	.007	11	Long.
		Lal. 6889			9.2	. . .	+ .059	.005	11	Long.
18	+23.520	β 536	40.3	+23 53	8.2	A3	+ .004	.005	14	R. A.
19	+23.523	. . .	40.5	+23 57	6.96	A0	+ .030	.001	13	R. A.
20	+23.526	. . .	40.7	+23 48	9.5	F8	+ .013	.006	14	R. A.
21	+23.531	. . .	41.3	+23 49	8.7	G0	+ .017	.008	13	R. A.
22	+31.737	OΣ 77 *AB*	4 9.6	+31 27	7.40	F8	− .009	.006	13	R. A.
23	+31.738	OΣ 77 *C*	9.6	+31 27	9.0	F8	+ .034	.008	13	R. A.
24	+13.728	β 552	46.2	+13 29	6.70	F5	+ .019	.006	12	R. A.
25	+29.1009	β 560	5 42.9	+29 42	7.76	A5	+ .024	.011	12	R. A.
26	+30.1238	*RT Aurigæ*	6 22.1	+30 33	6.0(var.)	G0	+ .025	.004	13	R. A.
27	+59.1028	Σ 963 = 14 *Lyncis*	44.3	+59 34	5.44	F	.000	.006	12	R. A.

No.	B.D. Number	Name	R. A. (1900)	Declination (1900)	Magnitude	Spect.	Relative Parallax		No. of Plates	Coördinates
			h m	° ′			″	″		
28	+58.982	OΣ 159 = 15 *Lyncis*	48.6	+58 33	4.54	G0	+0.023 ±	0.014	12	R. A.
29	+16.1397	15 *Geminorum*	7 2.6	+16 5	5.58	K	+ .015	.009	13	R. A.
30	+27.1337	Σ 1037	6.6	+27 21	6.44	F5	+ .023	.007	13	R. A.
31	+21.1609	*N. G. C.* 2392	23.3	+21 7	Neb.	Pe	+ .006	.004	14	R. A.
32	+33.1585	π *Geminorum* = Σ 1135	41.1	+33 40	5.29	K2	+ .020	.008	14	R. A.
33	+ 6.2036	ε *Hydræ*	8 41.5	+ 6 47	3.48	F8	+ .012	.012	14	R. A.
34	+ 6.2040	ρ *Hydræ*	43.4	+ 6 12	4.12	A0	+ .012	.009	12	Long.
35	+ 9.2188	ω *Leonis* = Σ 1356	9 23.4	+ 9 30	5.52	G	+ .030	.004	12	Long.
36	+36.1979	11 *Leo Min.*	29.7	+36 16	5.48	K	+ .144	.011	12	R. A.
37	+32.1964	20 *Leo. Min.*	55.2	+32 25	5.60	F2	+ .012	.006	12	R. A.
38	+42.2162	*Pi* 10h, 191	10 50.5	+42 33	6.44	G5	+ .006	.009	12	R. A.
39	+45.2381	β 603	11 43.5	+44 50	5.90	A	+ .047	.009	16	R. A.
40	+42.2321	β *Can. Ven.*	12 29.0	+41 54	4.32	G0	+ .090	.015	12	R. A.
41	+35.2436	*H* 529	13 14.9	+35 39	9.3	Ma	+ .118	.009	14	R. A.
42	+37.2433	Σ 1768 = 25 *Can. Ven.*	33.0	+36 48	4.92	F0	+ .047	.015	13	R. A.
43	+27.2296	Σ 1785	44.5	+27 29	7.26	K2	+ .035	.007	12	R. A.
44	+ 9.2842	β 1270	58.8	+ 8 58	7.8	F5	+ .007	.011	12	R. A.
45	+ 3.2874	Σ 1819	14 10.3	+ 3 36	7.04	F8	+ .090	.010	14	R. A.
46	+ 7.3125	Σ 2026	16 11.1	+ 7 37	8.6	K5	+ .004	.006	12	R. A.
47	+21.2934	β *Herculis*	25.9	+21 42	2.84	K	+ .031	.009	14	R. A.
48	+ 1.3408	*U Ophiuchi*	17 11.5	+ 1 19	5.76(var.)	B8	.000	.011	13	R. A.
49		Barnard's Star	53.5	+ 4 27	9.7	Mb	+ .555	.006	12	R. A.
50	+ 3.3610	73 *Ophiuchi*	18 4.6	+ 3 59	5.67	K	+ .015	.009	14	R. A.
51	+ 3.3613	β 637	18 4.9	+ 3 6	5.73	F	+ .012	.013	17	R. A.
52	− 3.4334	*A* 88	33.1	− 3 17	6.47	F8	+ .019	.012	11	R. A.
53	+49.2874	β 971 = 205 *Draconis*	44.9	+49 19	7.18	F	+ .018	.006	13	R. A.
54	+13.3844	11 *Aquilæ* = Σ 2424	54.5	+13 29	5.37	A	+ .039	.010	12	R. A.
55	+49.2959	6 *Cygni* = Σ 2486	19 9.5	+49 40	6.81	. . .	+ .050	.018	15	R. A.
					6.62	K	+ .037	.017	15	R. A.
56	+30.3639	Campbell's Hydrogen Star	30.9	+30 48	9.3	. . .	− .002	.010	14	R. A.
57	+50.2869	*N. G. C.* 6826	42.1	+50 17	9.0	Neb.	− .006	.007	14	R. A.
58	+18.4254	ζ *Sagittæ* = Σ 2585	44.5	+18 53	4.95	A	+ .030	.007	17	R. A.
59	+34.3798	η *Cygni* = β 980	52.6	+34 49	4.03	K	+ .015	.014	12	R. A.
60	+16.4121	15 *Sagittæ*	59.6	+16 48	5.89	G	+ .064	.012	14	Long.
61	+35.4267	λ *Cygni* = OΣ 413	20 43.5	+36 7	4.47	B5	+ .023	.011	15	R. A.
62	− 6.5604	4 *Aquarii* = Σ 2729	46.1	− 6 0	5.96	F	+ .038	.011	17	R. A.
63	+ 6.4744	*Lal.* 40844	21 0.4	+ 6 41	8.8	K	+ .016	.007	13	R. A.
64	+37.4359	72 *Cygni*	30.7	+38 5	4.98	K	+ .013	.008	17	R. A.
65	+24.4463	κ *Pegasi*	40.1	+25 14	4.27	F	+ .032	.014	13	Long.
66	+45.3894	2 *Lacertæ*	22 16.9	+46 2	4.66	B5	+ .036	.009	14	R. A.
67	+69.1262	Σ 2924	30.4	+69 24	6.02	A	+ .005	.009	15	R. A.
68	+42.4592	6 *Andromedæ*	23 5.8	+43 0	5.85	A	+ .039	.014	12	Long.
69	+ 4.4994	β 80	13.8	+ 4 52	9.0	K	+ .008	.014	14	Long.
70	+31.4901	Br. 3109	18.9	+31 59	6.53	F2	+ .013	.009	14	Long.
71	+30.4963	β 1266	25.5	+30 47	7.26	. . .	+ .003	.009	12	Long.
72	+66.1679	Groom. 4220	59.5	+66 37	5.89	K	+ .022	.007	14	R. A.

It is of interest to compare the results of determinations of the parallaxes of the same stars made at different observatories. For this purpose the recent photographic determinations of Allegheny, Dearborn, McCormick, Mt. Wilson, Sproul, and Yerkes were used. Each determination was given the weight unity and

the average found in the 102 cases common to the Sproul Observatory program and the program of one or more of the other observatories. The differences are then formed in the order given in the following table. The results of the Sproul Observatory and the average parallaxes found are also compared with the spectroscopic determinations made by Adams and his colleagues.

This table does not purport to assign relative accuracies to the different observatories because all the Sproul parallaxes have been used and only those of the other observers which are common to the Sproul list; but it does compare results found for the same stars by different observers.

	No. of Cases	Algebraic Sum / No. of Cases	Arithmetic Sum / No. of Cases
Adams — Sproul	112	+0″.00028	0″.0215
Adams — Average	90	+0 .00307	0 .0157
Average — Sproul	102	+0 .00004	0 .0112
Average — Allegheny	54	+0 .00270	0 .0105
Average — McCormick	46	−0 .00030	0 .0109
Average — Yerkes	54	+0 .00528	0 .0154
Average — Van Maanen	18	−0 .00350	0 .0131
Average — Dearborn	8	−0 .02012	0 .0236

OBSERVATIONS DE PLANÈTES ET DE COMÈTES,

FAITES À L'OBSERVATOIRE DE BESANÇON, ÉQUATORIAL COUDÉ DE $0^m.33$ d'ouverture,

Par M. P. CHOFARDET.

Dates	T. m. Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log f.p.	Réd. au j.		★
					(5) *Astraea*						
1921	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Mai 6	10 0 0	+ 0 42.42	+ 3 4.3	9 , 6	11 11 20.44	9.260	78 43 8.5	0.722*n*	+2.04	+13.3	1
					(20) *Massalia*						
Févr. 11	9 44 41	+ 1 14.80	+ 5 55.2	9 , 6	8 20 12.04	9.104*n*	71 42 42.7	0.637*n*	+2.32	+14.6	2
12	9 55 36	+ 0 27.11	+ 2 53.1	9 , 6	8 19 24.35	8.996*n*	71 39 40.6	0.632*n*	+2.32	+14.6	2
Mars 3	10 35 32	− 1 9.26	− 3 10.5	9 , 6	8 10 18.77	9.106	71 0 51.6	0.628*n*	+2.20	+13.8	3
					(27) *Euterpe*						
Oct. 24	9 23 25	− 0 37.64	− 2 46.5	9 , 6	23 16 35.54	8.190	97 24 10.1	0.857*n*	+3.63	−24.4	4
26	7 1 10	− 1 9.08	− 1 17.3	9 , 6	23 16 4.08	9.294*n*	97 25 39.4	0.851*n*	+3.61	−24.3	4
27	7 10 48	− 1 22.90	− 0 46.9	9 , 6	23 15 50.25	9.244*n*	97 26 9.9	0.852*n*	+3.60	−24.2	4
31	6 44 40	− 1 59.15	− 0 57.0	9 , 12	23 15 13.96	9.280*n*	97 26 0.1	0.851*n*	+3.56	−23.9	4
Nov. 19	6 4 50	+ 1 50.32	+ 4 47.3	9 , 9	23 19 3.93	9.148*n*	96 41 55.9	0.850*n*	+3.35	−22.8	5
					(29) *Amphitrite*						
Oct. 24	9 58 36	+ 3 44.56	+11 56.8	9 , 12	0 44 7.81	8.786*n*	80 40 19.9	0.734*n*	+4.07	−24.2	6
					(51) *Nemausa*						
Sept. 27	9 2 55	+ 2 30.68	+ 6 13.6	9 , 12	22 2 3.22	8.787*n*	98 15 48.9	0.860*n*	+3.65	−25.3	7
28	8 44 28	+ 2 7.55	+13 19.9	9 , 12	22 1 40.08	9.934*n*	98 22 55.2	0.860*n*	+3.64	−25.3	7
29	8 40 36	− 2 3.49	− 5 38.1	9 , 12	22 1 18.23	8.921*n*	98 29 57.9	0.861*n*	+3.65	−25.2	8
30	8 45 5	− 3 29.25	− 3 33.7	9 , 12	22 0 57.62	8.845*n*	98 36 49.4	0.862*n*	+3.64	−25.2	9
Oct. 24	8 55 56	− 2 50.29	+ 0 22.7	9 , 12	22 0 47.36	9.062	100 27 50.4	0.870*n*	+3.36	−23.6	10
26	6 31 53	− 2 12.47	+ 4 39.2	9 , 12	22 1 25.16	9.096*n*	100 32 7.0	0.869*n*	+3.34	−23.5	10
27	6 45 55	− 1 50.18	+ 6 40.0	9 , 9	22 1 47.43	8.975*n*	100 34 7.9	0.871*n*	+3.32	−23.4	10
Nov. 17	6 10 24	+ 3 16.55	+ 7 6.5	9 , 12	22 14 38.56	8.568*n*	100 36 59.6	0.873*n*	+3.06	−22.1	11
18	6 15 20	+ 4 6.65	+ 5 30.7	9 , 12	22 15 28.64	8.294*n*	100 35 23.9	0.873*n*	+3.04	−22.0	11

Dates	T. m. Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log f.p.	Réd. au j.		★
					(54) *Alexandra*						
1921	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Nov. 23	7 11 11	+ 1 3.08	+10 22.8	9 , 6	1 26 52.06	9.363*n*	62 4 44.5	0.518*n*	+4.67	−24.3	12
24	7 27 19	+ 3 24.21	− 6 27.5	9 , 12	1 26 24.28	9.305*n*	62 11 50.4	0.506*n*	+4.63	−24.6	13
25	7 18 58	+ 2 55.62	+ 0 29.8	9 , 12	1 25 58.69	9.322*n*	62 18 47.7	0.511*n*	+4.63	−24.6	13
					(60) *Echo*						
Févr. 11	10 12 30	− 1 32.61	+ 1 32.6	9 , 6	8 25 1.94	8.923*n*	76 45 18.6	0.693*n*	+2.29	+15.4	14
12	10 13 28	− 0 15.80	+ 3 44.8	9 , 6	8 24 17.70	8.868*n*	76 39 55.6	0.692*n*	+2.29	+15.3	15
					(67) *Asia*						
Mai 6	11 5 18	− 2 29.31	−10 25.4	9 , 6	12 41 3.18	9.144	94 4 47.5	0.835*n*	+2.56	+11.4	16
10	10 28 24	+ 0 14.39	+ 5 42.8	9 , 6	12 39 13.67	9.029	93 42 37.5	0.834*n*	+2.52	+11.3	17
Juin 2	10 38 3	+ 1 8.73	− 1 57.1	9 , 6	12 37 1.39	9.122	92 36 7.2	0.824*n*	+2.32	+12.9	18
					(89) *Julia*						
Mars 12	10 17 15	+ 3 6.96	− 2 55.5	9 , 12	7 17 12.88	9.403	65 41 27.8	0.587*n*	+1.93	+10.0	19
					(97) *Clotho*						
Mai 31	10 49 55	− 2 2.68	+ 3 17.4	9 , 9	14 41 30.87	8.882	90 0 13.3	0.811*n*	+2.84	+ 5.3	20
					(106) *Dione*						
Févr. 11	10 48 38	− 0 41.85	+ 1 6.9	10 , 6	8 27 9.57	8.385*n*	64 41 10.2	0.515*n*	+2.39	+14.1	21
12	10 36 40	− 1 26.70	− 0 59.4	9 , 6	8 26 24.72	8.599*n*	64 39 3.8	0.515*n*	+2.39	+14.0	21
25	9 12 6	+ 2 15.59	− 3 48.6	9 , 6	8 18 14.87	8.943*n*	64 21 13.4	0.514*n*	+2.33	+12.8	22
Mars 1	10 1 59	+ 0 18.50	+ 3 54.9	9 , 6	8 16 23.86	8.631	64 19 19.7	0.509*n*	+2.30	+12.5	23
2	10 24 52	+ 0 23.90	+ 3 40.3	8 , 6	8 15 59.24	8.979	64 19 5.0	0.516*n*	+2.28	+12.4	23
					(135) *Hertha*						
Déc. 19	6 47 4	+ 4 28.04	+ 1 32.2	9 , 12	3 12 14.99	9.431*n*	68 24 18.4	0.632*n*	+4.92	−12.6	24
26	6 40 38	+ 1 32.94	+ 2 36.4	9 , 6	3 10 18.64	9.367*n*	68 41 23.6	0.621*n*	+4.88	−12.4	25
					(168) *Sibylla*						
Févr. 3	7 15 31	− 0 12.82	+ 6 32.9	12 , 15	3 3 10.43	9.070	75 46 43.6	0.685*n*	+1.19	+ 2.2	26
4	8 2 42	+ 0 28.03	+ 3 39.8	9 , 6	3 3 54.26	9.305	75 43 50.6	0.695*n*	+1.17	+ 2.3	26
					(172) *Baucis*						
Mars 8	9 56 46	− 0 10.05	− 2 58.3	9 , 6	9 41 8.21	8.858*n*	76 8 25.5	0.686*n*	+2.31	+16.5	27
9	9 52 52	− 1 31.88	− 3 10.5	9 , 6	9 40 46.10	8.817*n*	76 7 43.3	0.686*n*	+2.30	+16.5	27
10	9 12 23	− 2 22.34	− 4 17.5	9 , 12	9 39 25.94	8.907*n*	76 7 6.2	0.686*n*	+2.30	+16.4	27
12	11 3 8	− 0 11.72	− 0 11.8	9 , 6	9 37 45.51	8.911	76 6 6.7	0.686*n*	+2.28	+16.3	28
					(225) *Henrietta*						
Oct. 26	7 38 2	+ 1 48.12	+ 3 13.7	9 , 6	23 56 12.30	9.301*n*	84 50 43.2	0.776*n*	+3.84	−26.0	29
27	7 10 32	− 1 13.95	− 3 7.8	9 , 6	23 55 56.83	9.281*n*	85 0 29.6	0.777*n*	+3.84	−25.8	30
31	7 47 50	+ 2 18 13	− 4 37.5	9 , 12	23 55 6.18	9.183*n*	85 37 50.3	0.780*n*	+3.79	−25.8	31

Dates	T. m. Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log f.p.	Réd. au j.		★
					(250) *Bettina*						
1921	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Févr. 25	8 17 50	− 0 55.20	+ 7 0.1	12 , 9	8 6 17.04	9.280*n*	51 40 17.5	0.205*n*	+2.54	+ 9.6	32
Mars 1	8 49 0	+ 1 28.71	+ 5 34.1	9 , 6	8 1 39.62	8.936*n*	51 59 52.9	0.157*n*	+2.48	+ 9.0	33
2	9 58 57	− 1 3.90	− 1 1.4	9 , 6	8 4 19.38	8.888	52 5 22.2	0.158*n*	+2.46	+ 9.0	34
3	9 59 20	− 0 11.60	− 1 8.5	9 , 6	8 4 1.82	8.944	52 10 42.9	0.466*n*	+2.41	+ 8.9	35
					(258) *Tyche*						
Oct. 27	8 17 22	− 1 7.88	−12 29.3	9 , 6	0 56 1.73	9.355*n*	82 10 33.4	0.757*n*	+4.08	−23.0	36
Nov. 19	6 57 43	+ 2 31.88	− 2 56.5	9 , 12	0 51 51.24	9.308*n*	86 17 11.0	0.786*n*	+3.90	−22.1	37
23	6 44 37	+ 3 45.22	+ 7 58.3	9 , 12	0 52 35.94	9.301*n*	86 44 14.0	0.789*n*	+3.87	−21.8	38
24	6 45 15	− 4 18.30	− 9 7.6	9 , 12	0 52 51.34	9.286*n*	86 50 14.0	0.790*n*	+3.90	−21.2	39
25	6 43 15	− 4 1.40	− 3 26.7	9 , 12	0 53 8.23	9.280*n*	86 55 55.0	0.790*n*	+3.89	−21.1	39
26	6 39 57	− 2 26.07	− 5 42.7	9 , 12	0 53 26.84	9.279*n*	87 1 18.3	0.791*n*	+3.87	−21.1	40
					(266) *Aline*						
Oct. 31	7 13 17	− 0 9.76	− 5 25.5	9 , 6	23 31 5.06	9.238*n*	77 40 29.8	0.712*n*	+3.78	−28.5	41
Nov. 18	7 14 21	− 1 3.66	+ 7 4.9	9 , 6	23 35 30.72	8.754*n*	80 8 52.5	0.728*n*	+3.60	−27.5	42
19	6 26 12	+ 0 9.62	− 6 32.8	9 , 6	23 35 59.37	9.127*n*	80 15 2.9	0.732*n*	+3.58	−27.4	43
23	6 8 34	+ 2 16.82	− 6 57.9	9 , 12	23 38 13.74	9.149*n*	80 38 11.9	0.737*n*	+3.53	−27.1	44
24	6 15 33	+ 2 54.30	− 1 41.8	9 , 12	23 38 51.21	9.092*n*	80 43 28.0	0.736*n*	+3.52	−27.1	44
25	6 7 8	+ 3 32.68	+ 3 20.3	9 , 12	23 39 29.58	9.121*n*	80 48 30.1	0.737*n*	+3.51	−27.1	44
26	6 13 49	− 2 55.30	+ 0 26.5	9 , 12	23 40 10.00	9.064*n*	80 53 23.1	0.738*n*	+3.54	−26.7	45
					(346) *Hermentaria*						
Févr. 4	7 31 4	− 0 49.84	+10 9.9	9 , 6	3 8 8.12	9.150	76 6 40.6	0.692*n*	+1.20	+ 2.6	46
					(356) *Liguria*						
Mai 6	10 28 42	− 4 36.07	− 2 42.8	9 , 6	12 10 15.50	9.414	95 40 43.3	0.845*n*	+2.45	+16.2	47
					(386) *Siegena*						
Sept. 27	10 5 10	+ 0 59.99	+ 7 5.4	9 , 6	23 45 45.84	9.121*n*	98 41 44.8	0.860*n*	+3.78	−25.5	48
28	10 8 47	+ 2 52.06	− 9 11.4	9 , 12	23 45 9.53	9.074*n*	98 55 23.4	0.863*n*	+3.78	−25.1	49
29	10 27 56	+ 2 15.70	+ 3 53.9	9 , 12	23 44 33.17	8.890*n*	99 8 58.8	0.864*n*	+3.78	−25.0	49
30	10 3 33	+ 1 7.92	+ 2 17.4	9 , 6	23 43 58.20	9.050*n*	99 21 59.0	0.865*n*	+3.78	−24.9	50
					(433) *Eros*						
Sept. 28	9 18 23	− 2 26.52	+ 0 48.0	16 , 20	22 19 57.66	8.773*n*	76 55 44.9	0.694*n*	+3.72	−28.9	51
29	9 16 33	− 1 6.53	− 8 24.8	12 , 9	22 18 30.91	8.726*n*	77 1 39.8	0.695*n*	+3.70	−29.0	52
30	9 27 28	− 2 31.06	− 2 18.7	9 , 12	22 17 6.38	8.374*n*	77 7 45.8	0.695*n*	+3.70	−29.1	52
					(451) *Patientia*						
Févr. 4	6 55 53	+ 4 6.45	+ 2 0.9	9 , 12	2 6 41.15	9.255	87 18 33.0	0.792*n*	+0.69	+ 3.7	53
					(509) *Yolanda*						
Nov. 24	7 57 44	+ 1 27.12	+ 1 16.0	9 , 12	1 12 45.25	9.202*n*	79 39 34.7	0.729*n*	+4.25	−19.6	54
25	7 42 3	+ 0 53.42	− 3 45.6	9 , 12	1 12 25.90	9.251*n*	79 46 37.9	0.732*n*	+4.24	−19.5	55
26	7 2 10	+ 0 35.64	+ 3 3.0	9 , 6	1 12 8.09	9.366*n*	79 53 26.5	0.740*n*	+4.24	−19.5	55

Dates	T m Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log. f.p.	Réd. au j.		★
					(551) *Ortrud*						
1921	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Mars 8	10 33 38	+ 0 10.92	− 1 15.3	9 , 6	9 51 20.30	8.377*n*	76 36 17.8	0.690*n*	+2.32	+16.6	56
9	10 26 23	− 3 52.97	− 1 3.1	9 , 12	9 50 40.91	8.459*n*	76 33 2.1	0.689*n*	+2.31	+16.5	57
					(596) *Scheila*						
Mars 1	11 1 9	+ 1 51.56	+ 6 53.7	9 , 6	11 28 59.21	9.323*n*	62 8 52.0	0.507*n*	+2.27	+16.9	58
3	11 5 16	+ 0 10.55	− 4 55.9	9 , 6	11 27 15.22	9.270*n*	61 57 2.2	0.193*n*	+2.29	+16.7	58
8	11 5 26	+ 1 37.19	− 6 29.9	9 , 6	11 22 47.80	9.153*n*	61 31 8.9	0.469*n*	+2.34	+16.1	59
9	11 2 43	− 1 10.09	+ 5 51.5	9 , 6	11 21 53.66	9.141*n*	61 26 37.6	0.466*n*	+2.34	+16.0	60
10	10 19 55	− 2 2.97	+ 1 44.3	9 , 6	11 21 0.79	9.320*n*	61 22 30.3	0.491*n*	+2.35	+15.9	60
					(695) *Bella*						
Nov. 30	6 27 33	+ 0 18.39	+6 21.3	9 , 12	1 41 55.91	9.462*n*	61 19 50.7	0.535*n*	+4.76	−23.3	61
Déc. 3	6 56 19	+ 1 8.31	− 1 26.6	9 , 6	1 41 36.70	9.345*n*	61 54 27.6	0.509*n*	+4.71	−23.5	62
19	5 54 36	− 1 43.56	− 0 30.3	9 , 6	1 44 53.55	9.345*n*	64 31 29.3	0.555*n*	+4.53	−22.6	63
					(945) *Barcelona*						
Févr. 11	11 19 33	+ 1 48.14	+ 3 11.9	9 , 9	9 3 10.24	8.345	72 21 5.4	0.638*n*	+2.32	+15.7	64
12	11 18 46	− 0 17.22	− 1 7.5	9 , 6	9 1 35.08	8.380*n*	72 33 18.9	0.640*n*	+2.26	+15.8	65
					Comète *Reid* (1921*a*)						
Mars 30	16 30 49	− 0 16.91	+ 2 31.3	12 , 9	20 23 39.65	9.491*n*	97 46 44.8	0.838*n*	+0.72	− 5.2	66
31	16 13 59	+ 0 35.13	− 5 3.2	12 , 9	20 24 13.49	9.510*n*	96 50 56.6	0.833*n*	+0.75	− 5.1	67
Avril 1	15 50 49	+ 1 11.84	− 2 5.3	12 , 9	20 24 47.24	9.535*n*	95 52 44.9	0.827*n*	+0.77	− 4.9	68
3	16 5.55	+ 1 39.55	+ 7 13.7	12 , 9	20 25 57.07	9.506*n*	93 44 19.5	0.826*n*	+0.82	− 4.3	69
27	11 16 49	− 1 27.14	+ 2 14.1	9 , 10	20 52 17.92	9.777*n*	39 16 6.4	0.741*n*	+1.18	+ 6.9	70
27	11 30 58	− 1 25.17	+ 0 9.8	6 , 6	20 52 19.89	9.785*n*	39 14 2.1	0.722*n*	+1.18	+ 6.9	70
30	15 18 15	+ 3 25.57	+ 2 30.2	9 , 12	21 4 31.16	9.802*n*	27 54 21.4	9.723	+1.21	+ 7.8	71
Mai 30	10 18 48	+ 2 19.10	− 0 46.6	12 , 16	8 1 4.87	9.870	31 46 3.7	0.652*n*	+0.54	+ 1.6	72
31	10 6 50	+ 5 50.13	+ 2 58.6	9 , 12	8 2 1.24	9.863	32 33 19.6	0.637*n*	+0.54	+ 1.9	73
Juin 1	9 50 3	+ 2 4.01	+ 6 47.0	9 , 12	8 2 54.13	9.858	33 18 35.5	0.613*n*	+0.55	+ 2.1	74
2	9 58 55	− 0 13.61	+ 4 49.0	12 , 8	8 3 44.11	9.847	34 2 34.7	0.646*n*	+0.56	+ 2.2	75
7	10 27 43	− 3 3.10	− 7 13.4	3 , 4	8 7 14.46	9.789	37 17 46.7	0.748*n*	+0.58	+ 3.4	76
14	10 6 52	+ 1 54.60	− 0 34.4	9 , 12	8 11 1.28	9.754	40 55 49.5	0.767*n*	+0.59	+ 4.9	77
24	10 12 27	− 3 20.70	+ 7 36.6	9 , 6	8 15 27.50	9.682	44 55 4.5	0.831*n*	+0.62	+ 6.5	78
25	10 9 42	+ 1 16.32	+10 18.6	9 , 6	8 15 52.49	9.678	45 15 33.7	0.832*n*	+0.62	+ 6.8	79
					Comète Périodique *Pons-Winnecke* (1921 *b*)						
Avril 27	10 29 14	− 0 33.51	− 0 53.4	12 , 9	16 37 53.69	9.657*n*	17 22 24.7	0.400*n*	+2.22	+ 7.0	80
Mai 6	11 18 10	− 0 44.28	+ 6 18.8	12 , 9	17 11 29.29	9.526*n*	44 49 48.5	0.049*n*	+2.34	+ 4.8	81
10	11 19 30	+ 1 14.71	+ 5 32.1	9 , 6	17 30 7.86	9.604*n*	44 2 44.6	0.146*n*	+2.39	+ 3.8	82
31	11 15 53	+ 0 33.50	− 4 17.5	3 , 3	20 15 35.78	9.676*n*	50 14 53.5	0.530*n*	+2.52	− 1.0	83
31	11 56 19	+ 0 51.27	− 2 21.4	10 , 6	20 15 53.55	9.633*n*	50 16 49.6	0.448*n*	+2.52	− 1.0	83
Juin 2	11 14 35	+ 2 40.53	+ 0 26.8	9 , 12	20 37 12.40	9.672*n*	52 36 56.1	0.594*n*	+2.51	− 1.7	84

Positions moyennes des étoiles de Comparaison

★	A. R. 1921.0	D. P. 1921.0	Autorités	★	A. R. 1921.0	D. P. 1921.0	Autorités
	h m s	° ′ ″			h m s	° ′ ″	
1	11 10 35.98	78 39 50.9	*A.G. Leipzig I* 4237	43	23 35 46.17	80 22 3.4	*A.G. Leipzig II* 11721
2	8 18 54.92	71 36 32.9	*A.G. Berlin A* 3314	44	23 35 53.39	80 45 36.9	*A.G. Leipzig II* 11723
3	8 11 25.83	71 3 48.3	*A.G. Berlin A* 3257	45	23 43 1.76	80 53 23.3	*A.G. Leipzig II* 11767
4	23 17 9.55	97 27 21.0	*A.G. Wien-Ottak.* 8292	46	3 8 56.76	75 56 28.1	*A.G. Leipzig I* 964
5	23 17 10.26	96 37 31.4	*A.G. Wien-Ottak.* 8293	47	12 11 49.12	95 43 9.9	*A.G. Strasbourg* 4536
6	0 40 19.48	80 28 47.3	*A.G. Leipzig II* 240	48	23 44 42.07	98 35 4.9	*A.G. Wien-Ottak.* 8408
7	21 59 28.89	98 10 0.6	*A.G. Wien-Ottak.* 7910	49	23 42 13.69	99 5 29.9	*A.G. Wien-Ottak.* 8394
8	22 3 18.07	98 36 1.2	rap. à ★ 9	50	23 42 46.50	99 20 6.5	*A.G. Wien-Ottak.* 8399
9	22 4 23.23	98 40 48.3	*A.G. Wien-Ottak.* 7938	51	22 22 20.46	76 55 25.8	rap à *A.G. Lpz. I* 8974
10	22 3 34.29	100 27 51.3	*A.G. Harvard II* 7818	52	22 19 33.74	77 10 33.6	*A.G. Leipzig I* 8945
11	22 11 18.95	100 30 15.2	*A.G. Harvard II* 7862	53	2 2 31.01	87 16 28.4	*A.G. Albany* 594
12	1 25 44.31	61 54 46.0	*A.G. Cam.* 840	54	1 41 13.88	79 38 35.3	*A.G. Leipzig I* 526
13	1 22 58.44	62 18 42.5	*A.G. Cam.* 821	55	1 41 28.24	79 50 43.0	*A.G. Leipzig II* 663
14	8 26 32.26	76 43 30.6	*A.G. Leipzig I* 3429	56	9 50 37.06	76 37 46.5	rap à ★ 57
15	8 25 1.21	76 35 58.5	*A.G. Leipzig I* 3417	57	9 46 45.63	76 33 48.7	*A.G. Leipzig I* 3884
16	12 43 29.92	94 14 58.5	*A.G. Strasbourg* 4680	58	11 27 2.38	62 1 41.1	*A.G. Cam.* 5788
17	12 38 56.76	93 36 40.4	*A.G. Strasbourg* 4660	59	11 24 8.27	61 37 22.7	*A.G. Cam.* 5745
18	12 35 50.34	92 37 51.7	*Munich*$_1$ 8322	60	11 23 1.41	64 20 30.1	*A.G. Cam.* 5760
19	7 14 3.99	65 44 13.3	*A.G. Berlin B* 2886	61	1 41 32.76	61 13 52.7	*A.G. Cam.* 963
20	14 43 30.71	89 56 50.6	*A.G. Nicolajew* 3801	62	1 40 23.68	61 56 47.7	*A.G. Cam.* 950
21	8 27 49.03	64 39 49.2	*A.G. Cam.* 4571	63	1 46 32.58	64 32 22.2	*A.G. Cam.* 1014
22	8 15 56.95	64 24 49.2	*A.G. Cam.* 4488	64	9 1 19.78	72 17 37.8	*A.G. Berlin A* 3669
23	8 15 33.06	64 15 12.3	*A.G. Cam.* 4485	65	9 1 50.04	72 34 10.5	*A.G. Berlin A* 3673
24	3 8 12.03	68 22 58.5	*A.G. Berlin B* 940	66	20 23 55.84	97 44 18.7	*A.G. Wien-Ottak.* 7263
25	3 8 40.82	68 38 59.9	*A.G. Berlin B* 944	67	20 23 37.61	96 56 4.9	*A.G. Wien-Ottak.* 7261
26	3 3 22.06	75 40 8.5	*A.G. Leipzig I* 931	68	20 23 34.63	95 54 55.1	*A.G. Wien-Ottak.* 7260
27	9 41 45.98	76 11 7.3	*A.G. Leipzig I* 3856	69	20 24 16.70	93 37 10.1	*A.G. Strasbourg* 7085
28	9 37 54.95	76 6 32.2	*A.G. Leipzig I* 3840	70	20 53 43.88	39 43 45.4	*A.G. Harvard I* 6833
29	23 54 20.04	84 47 25.5	*A.G. Albany* 8242	71	21 1 7.38	27 54 43.4	rap à *A.G. Helsing* 11876
30	23 57 36.94	85 4 3.2	*A.G. Albany* 8230	72	7 58 15.23	34 46 48.7	*A.G. Helsingfors* 5355
31	23 52 44.26	85 42 53.6	*A.G. Albany* 8205	73	7 56 40.57	32 30 19.1	*A.G. Helsingfors* 5343
32	8 7 9.70	51 33 7.8	*A.G. Lund* 4112	74	8 0 49.57	33 14 46.4	*A.G. Helsingfors* 5377
33	8 3 8.43	51 54 9.8	*A.G. Lund* 4114	75	8 3 57.46	33 57 43.5	*A.G. Helsingfors* 5404
34	8 5 20.82	52 6 14.6	rap à ★ 35	76	8 10 16.98	37 24 56.7	*A.G. Harvard I* 3076
35	8 4 10.98	52 11 42.5	*A.G. Lund* 4119	77	8 9 6.09	40 56 19.0	*A.G. Bonn* 6164
36	0 57 5.53	82 23 25.7	*A.G. Leipzig II* 353	78	8 18 47.58	44 47 21.4	*A.G. Bonn* 6562
37	0 49 15.46	86 20 29.6	*A.G. Albany* 225	79	8 14 35.55	45 5 8.3	*A.G. Bonn* 6516
38	0 48 46.85	86 36 34.5	*A.G. Albany* 222	80	16 38 25.01	47 23 10.8	*A.G. Bonn* 10673
39	0 57 5.74	86 59 42.8	*A.G. Albany* 259	81	17 12 14.23	44 43 21.9	*A.G. Bonn* 11046
40	0 55 49.04	87 7 22.1	*A.G. Albany* 252	82	17 28 50.76	43 57 8.7	*A.G. Bonn* 11240
41	23 31 11.04	77 46 23.8	*A.G. Leipzig I* 9359	83	20 14 59.76	50 19 12.0	*A.G. Lund* 9222
42	23 36 30.78	80 2 15.1	*A.G. Leipzig II* 11726	84	20 34 29.36	52 46 31.0	*A.G. Lund* 9547

★ 8 − ★ 9	: Δ *A.R.* = −1ᵐ 5.16ˢ	; Δ *D.P.* = −4′ 47.1″	; *Cp.* = 9. 6
★ 34 − ★ 35	: Δ *A.R.* = +1 9.84	; Δ *D.P.* = −5 27.9	; *Cp.* = 9. 6
★ 51 − *A.G. Leipzig I* 8971	: Δ *A.R.* = −2 29.03	; Δ *D.P.* = −6 38.3	; *Cp.* = 12.16
★ 56 − ★ 57	: Δ *A.R.* = +3 51.43	; Δ *D.P.* = +3 57.8	; *Cp.* = 6. 8
★ 71 − *A.G. Helsingfors* 11876	: Δ *A.R.* = −1 12.22	; Δ *D.P.* = +5 54.3	; *Cp.* = 9. 9

REMARQUES

Comète *Reid* (1921 *a*) — Mars 30, dans un ciel éclairé par la *Lune*, encore forte, la Comète, estimée de 9e grandeur, apparait comme un amas nébuleux, sensiblement rond et large de 2′ à 3′, avec condensation bien définie, mais floue.

Avril 3, Comète de 8e grandeur, tête ronde de 3′ de diamètre, noyau flou décentré vers NE. Avril 27, la Comète est observée à travers un ciel très nébuleux. Avril 30, Comète de 5e à 6e grandeur, tetê ronde, large de 5′, noyau central assez bien défini. Mai 31, Comète de 6e grandeur, ronde et lumineuse, condensation centrale bien prononcée. Juin 7, le ciel se couvre. Juin 11, Comète peu visible, pointés difficiles: forte *Lune*. Juin 24, la Comète, dans le crépuscule, a l'aspect d'une nébulosité de 10e grandeur, de 1′ de diamètre, sans noyau bien certain.

Comète périodique *Pons-Winnecke* (1921 *b*) — Avril 27, la Comète de grandeur 12.5, peu visible, est pénible à observer. Mai 6, le ciel est nébuleux. Mai 10, la Comète est de 10e grandeur. Mai 31, 1re série, le ciel se couvre: 2me série, Comète de 9e grandeur, ronde, noyau central, chevelure étalée sur 4′ de diamètre.

Observatoire de Besançon,
1922, Mai 10.

MERIDIAN CIRCLE OBSERVATIONS OF FAINT STARS,

By R. H. TUCKER.

In the *Astronomical Journal*, No. 184, the occultation of a faint star by *Mars* was recorded. The observer, the late Dr. E. S. Holden, proposed at the time, July, 1888, that the star be observed here with the meridian circle. To the best of my knowledge no attention had since been paid to completing the record, until we recently received a request for the position.

The star was evidently *B. D.* −8° 3552, recorded as magnitude 10 by Schonfeld. At the occultation it was presumed to be as faint as magnitude 11. I commonly find the estimates of the southern *B. D.* to be brighter than those of the northern *B. D.* at the faint end of the scale, and the star thus identified is fainter than tenth magnitude.

Some other faint stars have been recently observed, some for possible occultations by the planets, and some for proper motion. The observed right ascensions have been corrected for my magnitude equation. The observations have been reduced with standard star places from the *American Ephemeris*. The corrections necessary to reduce to other systems have been computed.

Lick Observatory,
July 1922.

Star	Mag.	1922.0 α	1922.0 δ	Epoch	No. obs.
°		h m s	° ′ ″		
−4 3442	9.5	13 9 56.380	− 4 27 3.66	1922.38	2 E
−4 3459	9.5	13 15 34.882	− 5 5 52.50	.38	2 E
−8 3552	10.5	13 21 11.830	− 9 21 13.30	.38	2 E

Reduction to Auwers B. J. +0s.012 −0″.19
Reduction to Boss P. G. C. +0 .005 −0 .34

Star	Mag.	α	δ	Epoch	No. obs.
−14 4048	9.4	14 46 53.589	−15 10 23.46	.41	2 E
−14 4069	9.0	14 51 13.800	−15 1 27.92	.41	2 E
−15 4027	9.1	15 2 24.707	−15 50 30.50	.41	2 E

Reduction to Auwers B. J. −0s.005 −0″.15
Reduction to Boss P. G. C. +0 .002 −0 .20

Barnard's Proper Motion Star

Star	Mag.	α	δ	Epoch	No. obs.
Anon.	9.5	17 54 1.044	+ 4 28 46.34	.465	2 E

Reduction to Auwers B. J. −0s.008 −0″.14
Reduction to Boss P. G. C. −0 .003 −0 .38

Nova Aquilæ

Star	Mag.	α	δ	Epoch	No. obs.
−16 4706	9.2	18 1 46.827	−16 41 44.32	.49	2 E
Nova	9.5	18 44 55.703	+ 0 29 45.74	.49	2 E

Reduction to Auwers B. J. +0s.009 −0″.13
Reduction to Boss P. G. C. −0 .001 −0 .21

CONTENTS.

Editor, Benjamin Boss, Albany, N. Y.; Associate Editors: E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward
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THE MASSES OF VISUAL BINARY STARS,

By JOHN A. MILLER and JOHN H. PITMAN.

The original parallax program of Sproul Observatory was built around a desire to determine the masses of stars. Accordingly the program here contains all those visual binaries within our reach whose orbits are well determined, together with those whose orbits may be tolerably well known in the not too distant future. A very considerable number of binaries have been included in various parallax programs, so that trigonometric parallaxes have been determined, by one or more observatories, of a considerable number of these objects. Except in a few instances these trigonometric parallaxes have been determined photographically. In most cases the components of the double are so near each other that the combined images on our plates are sensibly round and in the measurements we have bisected this image.

The question naturally arose, as to whether or not the revolution of the close pairs would not change the shape of this image sufficiently to seriously vitiate the determinations of the parallax. Recently PROFESSOR PITMAN and MISS POWELL, an assistant at the Observatory, undertook to determine if possible the effect upon the parallax of this orbital motion. They used instead of the usual formula of reduction,

$$c + T\mu + P\pi = m,$$

the equation

$$c + T\mu + P\pi + \rho\frac{\sin\theta}{2} = m,$$

where ρ and θ are respectively the radius vector of the star in its orbit and the position angle. Fourteen stars were examined. Of these the parallaxes of eleven were changed by $0''.000$ or $0''.001$; one was changed by $0''.002$; one was changed by $0.''001$; and another was changed by $0''.009$.

The observations of the last star for parallax extended over a period of five years, and the stars were in that part of the orbit in which the position angle and also the distance changed very rapidly, the change in angle being 21°. The variation of ρ was from $0''.33$ to $0''.86$.

In making these investigations, only those stars were treated in which the brightness of the components differed by less than two magnitudes. The investigation seemed to indicate that the error introduced by revolution is smaller than the error of measurement, except in rare instances which can be avoided by examining the orbit. To convince ourselves more completely we compared the parallaxes of 33 single stars with those of 33 of the double stars discussed in the second part of this paper. These single stars were chosen at random in the following way: if the parallax of six double stars were determined by the Yerkes, Allegheny, and McCormick observers, then we chose six single stars at random whose parallaxes had been determined by the same set of observers, and found the average parallaxes and the residuals. We treated the double stars in the same manner. In all there were 33 pairs of double stars and hence 33 single ones. We found the algebraic average residual of the single stars to be $0''.003$ greater than that of the double stars. While this is not conclusive it is our opinion that the parallaxes of the double stars are as reliable as those of the single ones.

We have given below a list of all binary stars contained in our card catalogue of parallaxes whose orbits are known and whose parallax has been determined trigonometrically by one or more observers. In making the selections of the parallaxes used we have included all those parallaxes whose probable error is less than $0''.015$; in fact very few probable errors exceed $0''.010$. We have given equal weights to each observer. We found the average of these relative parallaxes, added $0''.005$ to this average for an absolute parallax, and computed their masses in the usual way. We have divided the stars into three groups. Group I contains those in which the orbit is well determined, where the parallax has been determined trigonomet-

rically by two or more observers, and the results are in fair accord. This group contains 27 systems.

Group II contains those stars whose orbits are less well determined or whose parallaxes have been determined by two or more observers and the results are discordant. This group contains 15 systems.

Group III contains all those stars for which there is only one parallax, where the parallaxes are very discordant, or the orbit very uncertain. This group contains 26 systems.

The results are shown in Table I below. Column 6 contains the average relative parallax as determined by the observers whose initials appear in Column 5. The initials have the following significance: A., Allegheny Observers; B., Barnard; C., Chase; D., Dearborn Observers; E., Elkin; G., Gill; H., Hall; K., Krueger; M., McCormick Observers; Mt. W., Mount Wilson Observers; R., Russell; S., Sproul Observers; Sm., Smith; Y., Yerkes Observers. We have included spectroscopic parallaxes determined by Adams and his colleagues in the table as well as the trigonometric values, but they are not included in the averages.

TABLE I

First Class

		R. A. (1900)	Mag.	Spec.	Observer	Parallax	Mass	Abs. Mag.
		h m				″		
1	*η Cass.*	0 43.0	3.6	F8	Ave. (A. M. R. S.)	0.180	1.11	4.93
					Adams	.141	2.35	4.35
2	β 524	2 17.4	5.24	F0	Ave. (Mt. W. S. Y.)	.013	0.63	1.52
					Adams	.022	0.30	1.95
3	Σ 518	4 10.7	9.14	A0	Ave. (G. H. M.)	.199	0.25	10.69
					Adams	.219	0.32	10.82
4	*Sirius*	6 40.8	−1.58	A	Ave. (E. G. Y.)	.381	3.01	1.33
					Adams	.376	3.26	1.31
5	*Castor*	7 28.2	1.58	A	Ave. (A. D. M. Sm. Y.)	.085	2.18	1.35
					Adams	.091	2.10	1.38
6	*Procyon*	7 34.1	0.5	F5	Ave. (E. M. S. Y.)	.309	1.41	2.98
					Adams	.347	1.05	3.20
7	42 *Com. Ber.*	13 05.1	4.45	F5	Ave. (A. Y.)	.061	1.66	3.55
					Adams	.055	2.87	3.15
8	β 612	13 34.8	5.55	F2	Ave. (A. M. S. Y.)	.006	16.11	0.76
					Adams	.011	16.11	0.76
9	β 1111	14 18.5	6.65	A0	Ave. (S. Y.)	.014	1.15	3.04
					Adams	.009	10.8	1.42
10	*α Centauri*	14 32.8	0.01	G5 K5	Gill and Elkin	.745	2.10	4.42
					Wright	.76	2.02	4.48
					Adams	.794	1.76	4.54
11	*η Cor. Bor.*	15 19.1	5.07	G0	Ave. (S. Y.)	.079	0.69	4.66
					Adams	.055	2.45	3.77
12	Σ 1938	15 20.7	6.71	K0	Ave. (A. M. S.)	.033	0.81	4.70
					Adams	.032	1.53	4.24
13	*γ Cor. Bor.*	15 38.6	3.93	A	Ave. (A. S. Y.)	.016	5.73	0.54
14	Σ 2052	16 21.5	7.01	G5	Ave. (A. M.)	.050	1.09	5.74
					Adams	.058	0.93	5.86
15	*ζ Herc.*	16 37.5	2.96	G0	Ave. (A. S. Y.)	.098	1.90	3.02
					Adams	.076	4.72	2.36
16	Σ 2107	16 47.9	6.76	F5	Ave. (A. S. Y.)	.018	1.02	3.57
					Adams	.021	0.93	3.47
17	Σ 2173	17 25.2	5.29	G	Ave. (S. Y.)	.059	2.15	4.32
					Adams	.063	2.25	4.29

		R. A. (1900)	Mag.	Spec.	Observer	Parallax	Mass	Abs. Mag
		h m				″		
18	*μ Herc.*	17 42.6	9.47	M6	Ave. (A. M.)	0.106	0.86	9.70
					Adams	.110	0.88	9.68
19	70 *Oph.*	18 0.4	4.04	K0	Ave. (A. K. M. S. Y.)	.187	1.82	5.56
					Adams	.187	1.97	5.40
20	99 *Herc.*	18 3.2	5.2	F8	Ave. (A. M. S.)	.037	6.45	3.32
					Adams	.069	1.45	1.39
21	A 88	18 33.2	6.45	F8	Ave. (S. Y.)	.024	1.52	3.76
					Adams	.032	1.13	3.98
22	*ε Equulei*	20 51.1	5.27	F5	Ave. (M. S.)	.020	1.53	2.26
					Adams	.019	3.49	1.66
23	*τ Cygni*	21 10.8	3.79	F0	Ave. (A. M. S. Y.)	.048	2.29	2.41
					Adams	.042	4.61	1.91
24	*κ Pegasi*	21 40.1	4.29	F5	Ave. (A. M. S. Y.)	.022	9.62	1.45
					Adams	.030	7.01	1.68
					Henroteau	.025	12.1	1.28
25	*Krueger* 60	22 24.5	9.06	M2	Ave. (A. B. D. M. R.)	.255	0.44	11.30
					Adams	.200	0.97	10.56
26	*β* 80	23 13.8	7.94	G	Ave. (D. M. S. Y.)	.017	3.87	4.65
					Adams	.030	1.53	5.33
27	85 *Pegasi*	23 56.9	5.80	G0	Ave. (A. S. Y.)	.090	0.93	5.69
					Adams	.091	1.06	5.70
					Second Class			
28	Σ 3062	0 1.0	6.44	G5	Ave. (M. S. Y.)	.013	45.95	2.42
					Adams	.048	2.42	4.55
29	*β* 513	1 53.7	4.60	A2	Ave. (M. S.)	.014	11.80	0.99
30	*γ Andr.*	1 57.8	5.09	A	Ave. (A. C. S.)	.004	18.8	0.06
					Adams	.033	0.38	2.68
31	*β* 883	4 45.7	7.45	F5	Ave. (A. S.)	.020	1.59	4.13
					Adams	.024	1.80	4.05
32	*ζ Cancri*	8 6.5	5.14	G0	Ave. (Y. S.)	.050	4.05	3.84
					Adams	.045	2.20	3.31
33	*ε Hydræ*	8 41.5	3.46	F8	Ave. (M. S.)	.008	23.7	−0.97
					Adams	.052	0.37	+2.04
					Aitken	.025	3.33	0.54
34	Σ 1888	14 46.8	4.62	G5	Ave. (A. M.)	.174	0.84	5.88
					Adams	.158	1.22	5.68
35	Σ 1909	15 0.5	4.91	G0	Ave. (A. Y.)	.075	2.31	4.37
					Adams	.066	3.06	4.01
36	*ξ Scorpii*	15 58.9	4.19	F5	Ave. (M. Y.)	.041	1.92	2.60
					Adams	.036	2.71	1.97
37	Σ 2055	16 25.9	3.94	A0	Ave. (A. M. S. Y.)	.003	105.5	−1.54
38	*β* 648	18 53.5	5.15	G0	Ave. (A. S.)	.090	0.62	5.01
					Adams	.083	0.79	4.75
39	*Secchi* 2	19 7.8	7.95	G5	Ave. (A. M. S. Y.)	.004	26.4	2.72
					Adams	.026	1.08	5.02
40	*ζ Sagittæ*	19 44.5	5.04	A2	Ave. (S. Y.)	.022	2.62	2.20

		R. A. (1900)	Mag.	Spec.	Observer	Parallax	Mass	Abs. Mag.
		h m				″		
41	*β Delphini*	20 32.9	3.64	F5	Ave. (M. S. Y.)	0.022	7.65	0.80
					Adams	.016	4.58	1.95
42	*δ Equulei*	21 9.5	4.56	F5	Ave. (A. M.)	.054	2.95	3.41
					Adams	.060	2.80	3.45
					Hussey	.074	1.69	3.96
					Third Class			
43	Ho. 212	0 30.1	5.18	F	Sproul	.048	2.04	3.80
					Adams	.042	4.04	3.30
44	β 395	0 32.2	5.69	K0	McCormick	.086	0.64	5.48
					Adams	.066	1.60	4.79
45	Σ 186	1 50.7	6.58	G0	Sproul	.042	0.77	4.94
					Adams	.047	.73	4.99
46	Σ 412	3 28.5	5.92	A2	Sproul	.006	1.08	1.12
47	OΣ 79	4 14.2	7.31	G0	Allegheny	.043	0.21	5.72
					Adams	.023	1.93	4.12
48	OΣ 82	4 17.4	7.68	G0	Allegheny	.028	2.41	5.27
					Adams	.024	6.26	4.58
49	β 552	4 46.2	6.93	F5	McCormick	.016	2.56	3.54
					Adams	.028	1.21	4.16
50	β101	7 17.2	5.31	G0	McCormick	.036	8.75	3.37
					Adams	.079	1.21	4.80
51	β581	7 58.8	7.95	G5	Sproul	.082	0.44	7.65
					Adams	.008	134.5	2.47
52	Σ 3121	9 12.0	6.99	K0	Sproul	.078	0.15	6.59
					Adams	.052	1.75	5.57
53	Σ 1356	9 23.1	5.18	G0	Sproul	.030	1.03	3.20
54	OΣ 234	11 25.4	6.75	F5	Sproul	.038	0.09	4.90
					Adams	.042	4.18	2.43
55	OΣ 235	11 26.7	5.51	F5	Sproul	.054	0.52	4.25
					Adams	.044	4.08	3.75
56	OΣ 269	13 28.3	6.67	A5	Sproul	.067	0.04	5.96
57	Σ 1768	13 33.0	4.93	F0	Sproul	.047	0.24	3.54
58	Σ 1785	13 44.5	7.03	K2	Sproul	.035	6.53	5.04
					Adams	.069	1.24	6.22
59	β 1270	13 58.8	7.89	F	Sproul	.007	5.83	3.29
60	OΣ 298	15 32.5	6.79	K0	Russell	.059	0.84	5.82
					Adams	.055	1.28	5.49
61	Σ 2026	16 11.1	7.85	K5	Sproul	.004	132.	2.32
62	*ζ Sagittarii*	18 56.2	2.74	A2	McCormick	.018	33.4	−0.15
63	Σ 2525	19 22.5	7.34	F8	Sproul	.013	1.94	3.62
64	*δ Cygni*	19 41.8	2.97	A	Sproul	.049	0.58	1.63
65	OΣ 387	19 45.0	6.84	F5	Sproul	.015	1.38	3.34
					Adams	.017	2.25	2.99
66	OΣ 400	20 6.9	7.44	G5	Sproul	.045	0.14	5.55
					Adams	.030	0.15	4.53
67	Σ 2729	20 46.1	6.04	F	Sproul	.038	0.18	4.18
68	β 1266	23 25.5	7.59	F5	Sproul	.003	20.4	2.10

We have collected in Table II, below, the masses of B-type stars determined from photometric and spectroscopic orbits, and also the masses of stars of other types as given in the first class of Table I. As is usual, the stars decrease regularly in mass from the earlier to the later types. The same general run is displayed in the results of the second and third classes but the individual results are not as accordant.

TABLE II

Type	B	A	F	G	K	M
No. of Obj.	8	8	11	6	3	2
Ave. Mass.	14.91	3.49	3.92	1.77	1.57	0.65

It has seemed to us for some time very desirable to determine absolute parallaxes by measure in some way. It would afford a check on our assumed parallaxes of comparison stars. It might even give us knowledge of systematic errors.

In May, 1886, RAMBAUT* presented a paper in which he showed that one may compute the absolute parallax of a binary if the elements of its visual orbit and the relative radial velocity of its components are known. HUSSEY† computed the parallax of *ξ Equulei* by means of RAMBAUT's formulæ in 1903. WRIGHT‡ in 1904 derived similar formulæ by adapting the work of LEHMAN-FELHES. He computed the absolute parallax of *α Centauri* using the following formula:

$$\pi'' = \frac{a'' \sin i \; n \, [e \cos \omega + \cos (v + \omega)]}{V \sqrt{1 - e^2}}$$

In this formula π is the parallax in seconds, n is mean angular motion in radians per second, and V is the relative radial velocity of the two components. The other symbols are those usually used for the elements of the orbit of the star.

The question arises how much a given set of errors in the elements would affect the parallax. We chose *Ho* 212, gave its elements the following increments: $da = 0''.01$; $di = 3°$; $dn = 0$; $de = .01$; $d\omega = 1°$; $dv = \frac{1}{2}$ km. per sec. and computed the resulting increment of the parallax. If we assume all the errors are positive, which is extremely improbable, the resulting increment in the parallax is $+0''.003$.

It is evident that if i is small that V will be too small for accurate determination. We have selected from Table I, 18 stars, for which i is sufficiently large, whose components were nearly equal in magnitude, the type of which will produce a good spectrum, and computed V for 1922. We have also computed the maximum V and the date when it occurs. The results are given in Table III below and indicate that the absolute parallaxes of a certain number of these stars might be obtained without an inordinate expenditure of time and energy.

Swarthmore, Pa.,
Feb. 18, 1922.

Proc. Royal Irish Academy, Vol. IV, (Sec. Ser.), No. 6.

†*Aph. Journal*, Vol. XVII, Page 378.

‡*Lick Observatory Bulletin*, Vol. III, Page 3.

TABLE III

	Star	R. A.	Sp.	Mag.	a	P	Rad. Vel. 1922	Max. Rel. Vel.	Date
		h m			"	y	km sec	km sec.	
1	Ho 242	0 30	F	5.6 6.1	0.242	6.88	9	32	1925
2	β 395	0 33	K0	6.4-6.5	0.66	25.0	4	15	1939
3	*Castor*	7 28	A	2.0 2.8	5.756	346.82	6.7	6.7	2050
4	β 101	7 47	G0	5.8 6.4	0.69	23.4	7 13	20 40	1939
5	ξ *Ursa Maj.*	11 13	G0	4.4 4.9	2.513	59.81	6	10	1939
6	γ *Virginis*	12 36	F	3.6 3.7	3.74	182.3	1	10	1886
7	42 *Coma Ber.*	13 05	F5	5.2 5.2	0.674	25.335	0	13	1935
8	β 612	13 34	F2	6.3 6.3	0.225	23.05	8	25	1930
9	Σ 1865	14 36	A2	4.4 4.8	0.62	130.	2	20	1898
10	Σ 1909	15 00	G0	5.3 6.2	3.58	201.7	2	10	1998
11	ξ *Scorpii*	15 59	F8	4.8 5.1	0.72	44.7	2	11 18	1950
12	Σ 2173	17 25	G	5.9 6.2	1.06	46.0	12	13	1924
13	A 88	18 33	F8	7.2 7.2	0.176	12.12	0	13	1924
14	ζ *Sagittarii*	18 56	A2	3.4 3.6	0.565	21.17	35	39	1939
15	ζ *Sagittæ*	19 44	A2	5.4-6.4	0.32	25.2	5	32	1935
16	β *Delphini*	20 32	F5	4.0-5.0	0.48	26.79	10	21	1936
17	ε *Equulei*	20 54	F5	5.8 6.3	0.64	97.4	3	19-24	1971
18	κ *Pegasi*	21 40	F5	5.0-5.1	0.29	11.35	28	32	1932

ELEMENTS AND FINDING EPHEMERIS OF [1921 W19],

By ELEANOR A. LAMSON.

[Communicated by Captain W. D. MacDougall, Superintendent, U. S. Naval Observatory.]

In November 1921, Mr. Geo. H. Peters found an object, which he suspected to be a new asteroid, on some photographic plates which he had exposed for the purpose of obtaining the asteroid (433) *Eros*. He made a number of photographs of the suspicious object during the next two months and from his plate measures the following provisional elements and a finding ephemeris for the next opposition have been computed. The elements are based upon the plate measures of Nov. 25, Dec. 9, Dec. 22, 1921 and Jan. 7, 1922.

Mr. Peters suggests the name *Anacostia* for this asteroid, in case it is new.

Provisional Elements

Epoch: 1921, Dec. 9.5 Greenwich Mean Time

$$
\begin{aligned}
M &= 7^\circ\ 7'\ 33''.3 \\
\pi &= 359\ 32\ 26.2 \\
\omega &= 74\ 44\ 32.5 \\
\Omega &= 284\ 47\ 53.7 \\
i &= 15\ 59\ 31.3 \\
\varphi &= 15\ 18\ 31.6
\end{aligned}
\quad \left.\begin{matrix}\\ \\ \\ \\ \end{matrix}\right\} 1923.0
$$

$$\mu = 672''.527$$
$$\log a = 0.481534$$

Heliocentric Co-ordinates 1923.0

$$
\begin{aligned}
x &= r[9.984019] \sin (90^\circ\ 6'\ 31''.4 + v) \\
y &= r[9.951575] \sin (352\ 10\ 8\ .9 + v) \\
z &= r[9.716360] \sin (27\ 4\ 21\ .0 + v)
\end{aligned}
$$

Comparison of Observations with Ephemeris Based Upon the Elements

Date	$\Delta\alpha$ (O–C)	$\Delta\delta$ (O–C)
1921	s	″
Nov. 21	−0.4	+ 9
25	−0.2	− 1
29	+0.3	−10
Dec. 1	+0.2	−14
3	+0.9	−13
9	+0.5	−20
22	+0.4	−18
27	+0.6	− 7
1922		
Jan. 2	+0.5	− 3
7	0.0	0
14	+0.3	+16
24	0.0	+40
25	+0.1	+43

Finding Ephemeris Greenwich Mean Midnight, 1923.0

Date	α	δ	log ρ	Date	α	δ	log ρ
1922	h m s	° ′ ″		1922	h m s	° ′ ″	
Oct. 29	8 0 47.8	+22 49 14	0.41768	Dec. 24	7 45 59.6	+19 57 29	0.33111
Nov. 2	8 1 54.2	+22 32 49	0.41008	28	7 42 17.7	+19 49 15	0.32918
6	8 3 7.6	+22 16 58	0.40245	1923			
10	8 3 57.4	+22 1 43	0.39484	Jan. 1	7 38 25.3	+19 41 14	0.32820
14	8 4 22.6	+21 47 7	0.38728	5	7 34 26.1	+19 33 23	0.32821
18	8 4 22.5	+21 33 14	0.37986	9	7 30 23.8	+19 25 40	0.32922
22	8 3 56.8	+21 20 2	0.37263	13	7 26 22.1	+19 18 2	0.33125
26	8 3 5.3	+21 7 34	0.36566	17	7 22 25.0	+19 10 27	0.33427
30	8 1 48.3	+20 55 47	0.35904	21	7 18 36.5	+19 2 56	0.33825
Dec. 4	8 0 6.4	+20 44 39	0.35284	25	7 14 59.9	+18 55 28	0.34316
8	7 58 0.0	+20 34 11	0.34715	29	7 11 38.2	+18 48 4	0.34891
12	7 55 30.2	+20 24 18	0.34205	Feb. 2	7 8 34.2	+18 40 45	0.35543
16	7 52 38.8	+20 14 56	0.33761				
20	7 49 27.7	+20 6 1	0.33394	Opposition Jan. 11, 1923		Mag. at Opposition = $10^m.3$.	

PRELIMINARY RESULTS OF THE RESEARCHES ON THE CLOSE APPROACH OF WOLF'S PERIODIC COMET TO *JUPITER* IN 1922,

By M. KAMENSKY.

The present article contains the first results of my computations on the close approach of WOLF's periodic comet to *Jupiter* in 1922. Though they are not quite finished, nevertheless I take the liberty to publish them now, bearing in mind the general scientific interest of similar problems. The more detailed results will be published in the near future.

The system K''_{10} of the elements of the comet was taken as basis of the researches and calculations. This system represents pretty well the observed places of the comet through its six returns to the *Sun* during 1884-1919:

1918 Dec. 16.0 B. M. T.

$$K''_{10}\left\{\begin{array}{l} M = 0^\circ\ 21'\ 35''.5 \\ \varphi = 33\ \ 57\ \ 58\ .2 \\ \Omega = 206\ \ 42\ \ 12\ .6 \\ \pi = 19\ \ 39\ \ \ 7\ .5 \\ i = 25\ \ 17\ \ 30\ .9 \\ n = 522''.7076 \end{array}\right. \quad \left.\begin{array}{l}\Omega\\ \pi \\ i\end{array}\right\} 1920.0$$

With the help of this system of the elements I have calculated the perturbations of the first order in the motion of the comet, due to *Jupiter* during the period 1918 Dec. 16.0–1922 Jan. 9.0. As they are not too large, we may suppose that the system of the elements for 1922 Jan. 9.0 is near the truth, neglecting the perturbations of the second order. Thus I get:

Perturbations for the period 1918 Dec. 16.0–1922 Jan. 9.0	System of the elements for 1922 Jan. 9.0 B.M.T.
$\delta M = +30'\ 50''$	$M = 163^\circ\ 29'.6$
$\delta\varphi = +19\ \ 23$	$\varphi = 34\ \ 17\ .4$
$\delta\Omega = -41\ \ 50$	$\Omega = 206\ \ \ 0\ .9$ } 1920.0
$\delta\pi = -21\ \ \ 9$	$\pi = 19\ \ 15\ .0$ } 1920.0
$\delta i = +34\ \ 27$	$i = 25\ \ 52\ .0$ } 1920.0
$\delta n = +\ 2''.652$	$n = 525''.360$

Then, with the help of the above system for 1922 Jan. 9.0, I computed the *exact* values of the perturbations, due to *Jupiter*, for the period 1922 Jan. 9.0–1922 Dec. 15.0. While calculating, I put the interval $\lambda =$ 10 days, and not only changed the elements every 10 days, but even made two or three successive approximations, in order to obtain the definitive differentials of perturbations near enough to those taken in the beginning of the calculations. Thus I get the following systems:

Entrance into the sphere of activity	Exit from the sphere of activity	Perturbations during the period
$\Delta = 0.3306$	$\Delta = 0.3214$	
1922 July 8.0 B.M.T.	1922 Dec. 15.0 B.M.T.	July 8 — Dec. 15, 1922
$M = 191^\circ\ \ 9'.0$	$M = 235^\circ\ 12'.4$	$\delta M = +\ 20^\circ\ 33'.9$
$\varphi = 34\ \ 44\ .3$	$\varphi = 24\ \ 25\ .2$	$\delta\varphi = -\ 10\ \ 19\ .1$
$\Omega = 205\ \ 35\ .2$	$\Omega = 205\ \ \ 2\ .6$	$\delta\Omega = -\ \ 0\ \ 32\ .6$
$\pi = 18\ \ 46\ .2$	A: $\pi = 4\ \ 49\ .0$	$\delta\pi = -\ 13\ \ 57\ .2$
$i = 27\ \ 39\ .1$	$i = 29\ \ \ 3\ .9$	$\delta i = +\ \ 1\ \ 24\ .8$
$n = 528''.438$	$n = 428''.532$	$\delta n = -99''.906$

The least distance between the comet and *Jupiter* occurs Sept. 26, 1922, when $\Delta = 0.1220$

On the other hand, calculating the jovicentric elements with the help of the above system of elements for 1922 July 8.0, I arrived at the following hyperbolic system:

$$\begin{aligned} T &= 1922\ \text{Sept.}\ 27^{d}.122\ \text{B.M.T.} \\ e &= 6.4197 \\ \Omega &= 131^\circ\ 35'.3 \\ \omega &= 323^\circ\ 47'.2 \\ i &= 122^\circ\ 35'.6 \\ a &= -0.022751 \end{aligned}$$

$$r_{\text{min.}} = q = 0.1233$$

Further, neglecting the perturbations due to the *Sun* for the period July 8–Dec. 15, I get the following system of the transformed heliocentric elemets, for the moment of the exit of the comet from the sphere of activity ($\Delta = 0.3208$).

1922 Dec. 15.0 B.M.T.

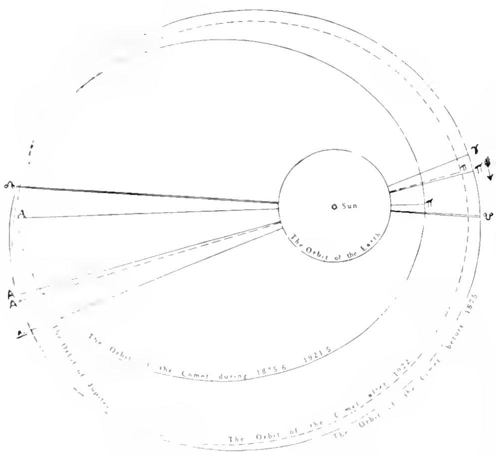
$$B \begin{cases} M = 235^\circ\ 26'.1 \\ \varphi = 25\quad 0.9 \\ \Omega = 205\quad 5.8 \\ \pi = 5\quad 7.7 \\ i = 29\quad 3.9 \\ n = 132''.63 \end{cases} \quad (\Omega, \pi, i: 1920.0)$$

The accordance between the systems A and B is good enough, especially when we take into consideration the neglect of the influence of the *Sun* on system *B* and the computation of the perturbations with 4-place tables, which is sufficient for the first approximation only.

It is very interesting to compare system A with that which existed before the close approach of the comet to *Jupiter* in 1875. According to *Lehmann-Filhes* (A.N. Band 124, p. 1), the main results of the transformation of the comet's orbit for that time are as follows:

Entrance into the sphere of activity 1875 April 5.0	Exit from the sphere of activity 1875 August 13.0	Perturbations
$M = 226^\circ\ 32'.6$	$M = 230^\circ\ 17'.6$	$\delta M = -\ 11^\circ\ 15'.6$
$\varphi = 23\quad 1.2$	$\varphi = 34\quad 32.5$	$\delta\varphi = +\ 11\quad 31.3$
$\Omega = 208\quad 26.8$ (1880.0)	$\Omega = 207\quad 40.8$ (1880.0)	$\delta\Omega = -\ 0\quad 46.0$
$\pi = 5\quad 39.2$ (1880.0)	$\pi = 18\quad 19.0$ (1880.0)	$\delta\pi = +\ 12\quad 39.8$
$i = 29\quad 26.6$ (1880.0)	$i = 27\quad 27.4$ (1880.0)	$\delta i = -\ 1\quad 59.2$
$n = 115''.668$	$n = 520''.011$	$\delta n = +104''.343$

The least distance $\Delta_{min.} = 0.1213$ was in June 1875.



As may be seen from these comparisons, the influence of *Jupiter* during the period 1922 July 8–1922 Dec. 15 was inverse to that for the period 1875 Apr. 5–1875 Aug. 13, and the orbit returned nearly to its original form.

The comet will pass its perihelion Oct. 28d.4, 1925; then its distance from the *Sun* will be about $r = 2.40$.

The earth at that time will be in that part of its orbit which lies approximately in the direction of the comet's perihelion, and the reciprocal distance of the two bodies will be approximately $2.40 - 1.00 = 1.40$.

Therefore we may expect that the comet, notwithstanding the enormous transformation of its orbit in 1922, may be observed with large telescopes, both visually and photographically.

All these changes may be readily seen on the accompanying diagram.

Yellow Sea,
April, 1922.

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Editor, Benjamin Boss, Albany, N. Y.; Associate Editors: E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward.
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PARALLAXES OF ONE HUNDRED AND TWO STARS,

DETERMINED BY PHOTOGRAPHY WITH THE 26-INCH MCCORMICK REFRACTOR,

By S. A. MITCHELL, and others.

The present list of parallaxes is a continuation of those published in *A. J.* Nos. 778, 796 and 803. As in the preceding lists a comparison is made with the spectroscopic parallaxes of Mt. Wilson to which the usual correction of 0″.005 is applied to reduce to relative parallaxes, the average McCormick comparison star being of approximately tenth visual magnitude. In the proper-motion column an asterisk denotes that the value is taken from the *Cincinnati Publications*, 18. Owing to changes in the personnel of the observatory staff the director has usually been in the habit of completing the measures started on a parallax series, but not finished, by one of the junior assistants. The absence of designation in the column of *Notes* signifies that the complete series of plates was measured by the writer. Full details of the measurements will appear in volume IV of the Publications of the Leander McCormick Observatory.

Most of the stars completed on the McCormick program to date belong to the later types of F, G, K, and M. However, 15 stars of B-type have been finished, and also 57 stars of type A. In addition, 22 *Cepheids* or pseudo-*Cepheids* have been measured and 49 stars of magnitude 3.0 or brighter. In the present list appears *Sirius* of visual magnitude −1.6. By a method described at the meeting of the American Astronomical Society at Northampton the image of *Sirius* was reduced by 11.6 stellar magnitudes on the photographic plate until it had the diameter of a star of the tenth magnitude.

The values of the McCormick parallaxes below are, as usual, the observed or relative parallaxes. To obtain the absolute parallax 0″.005 should be added to the relative value.

No.	Star	R.A. 1900	Decl. 1900	Mag. and Spectrum	″	Parallax McCormick		Parallax Spect. −0″.005	Proper-motion Observed	Proper-motion Boss	Notes
		h m	° ′		″	″	″	″	″	″	
342	ε *Andromedæ*	0 33.3	+28 46	1.5 G5	0.336	+0.017	±0.011	0.009	−0.221	−0.228	*b*
343	*Lalande* 1045	0 35.3	+39 40	7.5 K0	.797	+ .071	± .012	.053	+ .329	+ .346*	*c*
344	*Lalande* 2682	1 23.5	+21 13	7.9 G5	.495	+ .014	± .006	.015	+ .465	+ .456*	*a*
345	107 *Piscium*	1 37.1	+19 47	5.3 G5	.734	+ .143	± .009	.121	− .304	− .296	*c*
346	*Pi* 1h 159	1 40.5	+63 22	5.7 K0	.634	+ .109	± .008	.091	+ .578	+ .588	*c*
347	Boss 405	1 43.0	+32 11	5.8 F5	.354	+ .047	± .009	.035	− .204	− .175	*c*
348	α *Trianguli*	1 47.4	+29 6	3.6 F5	.233	+ .057	± .016	.028	+ .011	+ .017	*a*
349	84 *Ceti*	2 36.1	− 1 7	5.7 F5	.250	− .004	± .006	.031	+ .151	+ .210	*b*
350	θ *Persei*	2 37.4	+48 48	4.2 F8	.351	+ .081	± .011	.082	+ .324	+ .387	*b*
351	*i Persei*	3 1.8	+49 14	4.2 G0	1.269	+ .083	± .009	.105	+1.255	+1.267	*c*
352	94 *Ceti*	3 7.7	− 1 34	5.1 F8	.209	+ .040	± .010	.058	+ .172	+ .202	
353	*W. B.* 3h 147	3 11.0	− 6 17	6.0 B9	.24	+ .033	± .007	......	− .006	......	*c*
354	*Lalande* 7443	3 56.5	+35 2	8.6 G5	2.200	+ .045	± .009	.027	+1.767	+1.724	*a,d*
355	δ *Tauri*	4 17.2	+17 18	3.9 K0	.115	+ .011	± .008	.015	+ .096	+ .110	*c*
356	*A Oe* 4961	4 29.8	+52 42	8.5 K6	.53	+ .081	± .010	.095	+ .336	+ .272*	*a*

No.	Star	R.A. 1900	Decl. 1900	Mag. and Spectrum	″	Parallax McCormick	Parallax Spect. −0″.005	Proper-motion Observed	Proper-motion Boss	Notes
		h m	° ′		″	″ ″	″	″	″	
357	*Groom.* 864	4 34.5	+41 57	7.3 G0	0.690	+0.022 ±0.011	0.041	+0.560	+0.548*	*c*
358	Boss 1131	4 42.8	+18 32	6.8 G5	.440	+ .006 ± .010	.039	+ .177	+ .186	*c*
359	*Lalande* 9109	4 46.2	+13 29	6.7 F5	.43	+ .016 ± .013	.002	− .010	......	*c*
360	*A.G. Leid* 1812	4 51.3	+34 7	8.0 G5	.60	− .003 ± .011	.043	+ .569	+ .572*	*a*
361	13 *Orionis*	5 2.2	+ 9 21	6.3 G0	.381	+ .012 ± .009	.053	− .037	+ .005	*c*
362	*Lalande* 11196 *Br*	5 50.3	+13 56	6.5 G5	.629	+ .035 ± .007	.064	+ .382	+ .405*	*c*
363	*Lalande* 11196 *Ft*	5 50.3	+13 56	8.5 G5		.000 ± .009	....	− .011	....	*c*
364	1 *Geminorum*	5 58.0	+23 16	4.3 G5	.108	+ .033 ± .011	.031	− .036	− .008	*a*
365	*Sirius*	6 40.7	−16 35	−1.6 A0	1.316	+ .354 ± .008	.371	− .478	− .526	.
366	*Lalande* 13284	6 17.4	− 5 3	6.8 K2	.582	+ .059 ± .009	.110	− .555	− .583*	*a*
367	*A.G. Bonn* 5621	6 49.5	+40 13	8.3 K5	.43	+ .026 ± .011	.058	+ .121	+ .126*	*c*
368	*W.B.* 6h 1500...	6 51.4	+ 1 19	7.7 G5	.570	+ .038 ± .008	.033	+ .011	.000*	*b*
369	*Lalande* 15394	7 19.0	+19 31	7.9 K2	.471	+ .039 ± .014	.047	+ .084	+ .110*	*a*
370	*Lalande* 15547	7 53.6	+21 9	8.6 G5	.573	+ .014 ± .008	.020	+ .200	+ .179*	*c*
371	Boss 2236	8 20.7	+46 0	6.3 G0	.362	+ .057 ± .012	.047	− .025	− .032	*c*
372	32 *Lyncis*	8 26.9	+36 46	6.1 F2	.139	+ .025 ± .010	.020	− .164	− .139	*c*
373	*A.G. Camb.* 3184	8 28.3	+54 4	8.7 K0	.93	− .004 ± .011	.002	− .012	....	*b*
374	*Lalande* 16904	8 33.4	+56 3	8.1 G0	.470	− .011 ± .015	.024	− .234	− .284*	*c*
375	10 *Urs. Maj.*	8 54.2	+42 11	4.1 F5	.504	+ .073 ± .008	.061	− .414	− .431	*c*
376	81 *Cancri*	9 6.8	+15 24	6.4 G5	.576	+ .042 ± .008	.061	− .552	− .527	*d,a*
377	11 *Leo Minor.*	9 29.7	+36 16	5.5 K0	.753	+ .106 ± .009	.091	− .705	− .704	..
378	*W.B.* 9h 954...	9 46.1	−11 49	9.3 K	1.95	+ .078 ± .010	...	+1.161	+1.175*	*d*
379	*Groom.* 1596	9 54.9	+56 6	8.3 G5	.498	+ .030 ± .010	.025	− .163	− .197*	..
380	*Lalande* 19821	10 6.3	+24 15	8.6 G0	.414	+ .016 ± .014	.021	− .397	− .410*	*e*
381	39 *Leonis*	10 11.7	+23 36	5.8 F5	.423	+ .056 ± .011	.033	− .385	− .409	*e*
382	*W.B.* 10h 234	10 14.2	+20 22	9.2 Mdp	.490	+ .215 ± .007	.177	− .491	− .488*	..
383	*Groom.* 1646...	10 21.9	+49 19	6.5 Go	.898	+ .039 ± .009	.061	+ .097	+ .086	*c,d*
384	*Pi.* 10h 196....	10 27.7	+49 42	7.6 F8	.292	+ .051 ± .011	.017	+ .291	+ .313	*b,d*
385	*W.B.* 10h 520	10 31.6	−11 42	5.8 F8	.734	+ .042 ± .012	.037	+ .265	+ .265	*b*
386	Boss 2921	10 53.9	+36 40	6.2 Ma	.095	+ .018 ± .016	.004	+ .072	+ .077	*b*
387	*βG.C.* 5695. *B*	11 5.5	+31 0	9.8 Ma	.623	+ .078 ± .008	.058	+ .595	+ .590*	*c*
388	*βG.C.* 5695. *A*	11 5.6	+31 0	8.8 K5	.623	+ .087 ± .008	.078	+ .634		*c*
	βG.C. 5695 Mean					+ .082 ± .006				
389	83 *Leonis Br.*	11 21.7	+ 3 33	6.2 K0	.743	+ .040 ± .019	.053	− .703	− .721	*b*
390	83 *Leonis Ft.*	11 21.7	+ 3 32	7.9 K0	.736	+ .029 ± .018	.053	− .698	− .717	*b*
	83 *Leonis*, Mean					+ .031 ± .013				
391	62 *Urs. Maj.*	11 36.4	+32 48	5.7 F5	.317	+ .036 ± .012	.037	− .352	− .344	*c*
392	*Lalande* 22701	12 0.1	− 0 57	8.1 G5	.531	− .011 ± .010	.035	− .512	− .528*	*c*
393	*Lalande* 22954	12 10.0	− 9 44	6.1 F8	1.024	+ .012 ± .014	.028	+ .072	+ .051*	*c*
394	*η Corvi*	12 26.9	−15 38	4.4 F0	.444	+ .037 ± .013	.037	− .402	− .440	*a*
395	10 *Canis Ven.*	12 40.3	+39 40	6.0 F8	.375	+ .065 ± .010	.033	− .314	− .352	*a*
396	33 *Virginis*	12 44.5	+10 6	5.9 K0	.531	+ .015 ± .009	.041	+ .333	+ .271	*c*

No.	Star	R.A. 1900	Decl. 1900	Mag. and Spectrum	μ	Parallax McCormick	Parallax Spect. −0″.005	Proper-motion Observed	Proper-motion Boss	Notes
		h m	° ′		″	″ ″	″	″	″	
397	*B.D.* 1° 2756 . . .	12 45.6	+ 1 44	9.5	. . . .	+0.006 ±0.011	. . . . . .	+0.036	. . . .	. .
398	δ *Virginis*	12 50.6	+ 3 56	3.7 Ma	0.479	+ .008 ± .009	0.016	− .480	−0.470	*b,d*
399	*Lalande* 25012 . .	13 26.6	− 1 48	7.3 G5	.887	+ .019 ± .009	.047	− .888	− .846*	*c*
400	ξ *Virginis* . . .	13 29.6	− 0 5	3.4 A2	.288	+ .037 ± .013	.	− .286	− .286	*d*
401	τ *Bootis* .	13 42.5	+17 57	4.5 F5	.487	+ .070 ± .008	.045	− .463	− .485	*b,a*
402	14 *Bootis*	14 9.3	+13 26	5.5 F8	.267	+ .040 ± .013	.047	− .232	− .260	*c*
403	*Lalande* 26630	14 31.7	−11 53	6.2 F8	.946	+ .048 ± .010	.020	− .906	− .871	*c*
404	Boss 3736 .	14 33.6	+18 44	6.0 K0	.096	+ .011 ± .008	.010	− .024	− .028	*d*
405	*Lalande* 27137 .	14 48.9	+19 34	6.0 K0	.485	+ .079 ± .012	.090	− .440	− .435*	*b*
406	*Lalande* 27742	15 8.3	+19 39	6.8 G6	.668	.000 ± .010	.025	− .570	− .598*	*c*
407	*Lalande* 27743 .	15 8.3	+19 40	7.6 G7	.654	+ .013 ± .012	.028	− .564	− .589*	*c*
	*Lal.*27742-3, MEAN					+ .006 ± .009				
408	δ *Bootis* . .	15 11.5	+33 41	3.5 K0	.155	+ .018 ± .008	.010	+ .061	+ .089	*a,d*
409	39 *Serpentis* . . .	15 48.5	+13 31	6.2 G0	.586	+ .059 ± .010	.055	− .173	− .162	*a,d*
410	*Lalande* 29330 . .	16 1.2	+10 57	8.5 G5	.491	+ .005 ± .010	.027	− .525	− .490*	*c*
411	σ *Coronæ*, *Br.* . .	16 10.9	+34 7	5.8 G0	.302	+ .064 ± .014	.033	− .245	− .288	. .
412	σ *Coronæ*, *Ft.* . .	16 10.9	+34 7	6.7 G0	.302	+ .041 ± .010	.027	− .292		
	σ *Coronæ*. MEAN					+ .049 ± .008				
413	*Lalande* 30024	16 24.5	+18 38	7.0 K0	.508	+ .051 ± .010	.053	− .310	− .325*	*a*
414	*Lalande* 30044 .	16 25.6	+ 4 27	7.4 G0	1.450	+ .013 ± .011	.016	− .483	− .456	*d,b*
415	72 *Herculis* . .	17 16.9	+32 36	5.4 G0	1.060	+ .071 ± .011	.100	+ .150	+ .126	*d,a*
416	26 *Draco*	17 34.0	+61 57	5.3 F8	.763	+ .071 ± .010	.050	+ .242	+ .271	*d*
417	*Lalande* 32390 .	17 39.1	+21 41	7.4 K0	.623	+ .052 ± .009	.043	− .122	− .107	*b*
418	η *Serpentis* . . .	18 16.1	− 2 55	3.4 K0	.898	+ .070 ± .011	.061	− .563	− .564	*c*
419	*A.G. Lud.* 6797	18 37.1	+31 28	8.8 K3	.82	+ .030 ± .011	.031	+ .100	+ .051*	*b*
420	Σ 2398 *Br.* .	18 41.8	+59 29	8.8 K5	2.307	+ .312 ± .009	.235	−1.329	−1.313*	*a*
421	Σ 2398 *Ft.* . . .	18 41.8	+59 29	9.3	2.307	+ .293 ± .011	.	−1.391		*a*
	Σ 2398 MEAN .					+ .304 ± .007				
422	*Munich* 18180 . .	18 53.1	+ 5 49	9.7 K5	1.247	+ .092 ± .009	.090	− .213	− .211*	*c,d*
423	*Brad.* 2388	18 53.3	+32 46	5.2 G0	.235	+ .057 ± .008	.078	+ .181	+ .170	*c*
424	*Munich* 18816 . .	19 2.2	+ 7 29	9.5 K5	.812	+ .013 ± .010	.041	− .314	− .298*	*a,d*
425	*Groom.* 2875	19 29.5	+58 23	6.7 K4	.664	+ .026 ± .009	.095	− .556	− .533*	*c*
426	δ *Sagittæ*	19 42.9	+18 17	3.8 Ma	.009	+ .013 ± .010	.014	.000	+ .001	*c*
427	ε *Draco*	19 48.5	+70 1	4.0 G2	.087	− .004 ± .009	.017	+ .085	+ .081	*b*
428	*Lalande* 38380 .	19 59.5	+29 38	5.7 G7	.853	+ .042 ± .009	.061	+ .671	+ .669	*a*
429	15 *Sagittæ*	19 59.6	+16 48	5.9 G1	.578	+ .029 ± .010	.061	− .407	− .403	*b*
430	*A.G.Harv.I* 6486	20 15.9	+55 5	7.4 F3	.021	− .017 ± .010	.007	+ .001	.	*c*
431	*A.G.Harv.I* 6487	20 15.9	+55 5	C.0 A		− .021 ± .009		− .004	. . .	*c*
	A.G.Harv.I 6486-7 MEAN					− .019 ± .007				
432	*A Oe.* 20452	20 17.7	−21 40	8.2 F6	1.182	.000 ± .012	.008	+ .518	+ .512*	*b*
433	*Lalande* 39866 . . .	20 34.6	+ 4 37	8.4 K5	.844	+ .071 ± .009	.078	+ .896	+ .842*	*d*

No.	Star	R.A. 1900	Decl. 1900	Mag. and Spectrum	π	Parallax: McCormick		Parallax: Spect. −0″.005	Proper-motion: Observed	Proper-motion: Boss	Notes
		h m	° ′		″	″	″	″	″	″	
134	*ξ Cygni*	21 1.3	+43 32	3.9 K2p	0.007	+0.014	±0.010	−0.001	−0.003	+0.007	*a*
135	*W.B.* 21h 97	21 7.4	+17 21	7.3 F1	.915	+ .051	± .014	.017	− .152	− .117*	*b*
136	*A.G. Leid.* 8366	21 39.7	+21 53	9.4 K0	.65	+ .032	± .010	.020	− .394	− .381*	*c*
137	*W.B.* 22h 82	22 5.8	+22 18	8.8 K4	.60	− .005	± .010	.031	− .757	− .590*	*e*
138	*σ Pegasi*	22 47.3	+ 9 18	5.3 F4	.516	+ .017	± .012	.033	+ .505	+ .514	*e*
139	*Fed.* 4371	23 1.2	+67 52	7.5 G6	.615	+ .052	± .006	.039	+ .570	+ .592*	*e*
140	*Lalande* 45292	23 4.0	− 2 48	8.3 K4	.587	+ .013	± .012	.039	+ .607	+ .582*	*e*
141	6 *Andromedae*	23 5.8	+43 0	5.8 F5	.275	+ .052	± .007	.033	− .193	− .201	*e*
142	*W.B.* 23h 849	23 40.0	+29 0	8.9 K4	.91	+ .005	± .012	.021	+ .965	+ .908*	*d*

a partially measured by Miss Darkow
b partially measured by Miss Hawes
c partially measured by Miss France
d partially measured by Miss Mott
e entirely measured by Miss Mott

Leander McCormick Observatory, University of Virginia, July 15, 1922.

OBSERVATIONS OF THE SATELLITES OF *SATURN*, 1912-13,

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

By H. E. BURTON

[Communicated by Captain W. D. MacDougall, U. S. Navy, Superintendent of U. S. Naval Observatory]

Date	W. M. T.	*p*	W. M. T.	*s*	Comp.	Seeing	Power and Illum.	Remarks
				Mimas Tethys				
	h m s	°	h m s	″				
1912 Sept. 20	14 14 30	78 10	14 16 26	70 46	1, 1	3	495b, Brt.	
20	15 4 28	73 74	15 6 10	65 02	1, 1	3	495b, Brt.	
Oct. 1	14 55 5	278 86	14 56 18	17 79	4, 1	2	495b, Brt.	
1	13 53 21	285 55	13 54 15	16 05	1, 1	3	495b, Brt.	
5	14 0 3	89 61	14 2 10	77 43	1, 1	3	495b, Brt.	
10	15 50 3	255 85	15 51 12	51 02	1, 1	2	495b, Brt.	
15	12 53 50	296 73	12 52 57	26 83	1, 1	3 4	495b, Brt.	
28	14 25 20	318 66	14 24 56	24 15	1, 1	2	495b, Brt.	
29	14 13 48	240 67	14 16 16	54 26	1, 4	3	495b, Brt.	
Nov. 9	12 11 29	291 81	12 11 56	24 18	1, 1	3 4	495b, Brt.	
18	10 16 52	208 74	10 18 30	20 53	1, 1	2	495b, Brt.	
18	11 32 35	302 34	11 33 17	20 54	1, 1	2	495b, Brt.	
22	13 17 23	315 05	13 17 13	13 10	1, 1	1	495b, Brt.	
30	12 16 48	263 74	12 17 13	61 86	1, 1	2	367p, Brt.	
Dec. 9	14 54 27	328 43	14 53 17	14 46	1, 4	4	495p, Brt.	
14	8 34 32	89 25	8 34 2	75 43	1, 1	2	495b, Brt.	Interrupted by haze.
28	9 39 58	326 21	9 44 4	14 25	1, 1	3	495b, Brt.	
30	9 17 24	369 55	9 18 19	23 18	1, 1	3	495b, Brt.	
1913 Jan. 14	9 29 50	337 47	9 30 52	45 87	1, 1	2	495b, Brt.	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
				Mimas–Rhea				
	h m s	°	h m s	″				
1912 Sept. 20	14 39 8	280 50	14 39 34	64 35	4 , 4	3	495b, Brt.	
20	15 31 51	279 39	15 32 7	70 83	4 , 4	3	495b, Brt.	
Oct. 1	12 50 21	247 19	12 51 5	59 12	4 , 4	2	495b, Brt.	
4	14 17 4	246 37	14 15 30	51 75	4 , 4	3	495b, Brt.	
5	14 28 40	117 56	14 29 14	62 05	4 , 4	3	495b, Brt.	
15	12 23 20	95 40	12 24 3	59 58	4 , 4	3–4	495b, Brt.	
28	15 19 29	116 26	15 20 16	45 84	4 , 4	2	495b, Brt.	
29	13 6 59	57 63	13 7 59	49 59	4 , 4	3	495b, Brt.	
29	15 41 7	57 96	15 41 52	41 15	4 , 4	3	495b, Brt.	
Nov. 9	12 31 27	268 08	12 33 5	61 61	4 , 4	4	495b, Brt.	
18	11 11 32	261 90	11 13 22	115 59	4 , 4	2	495b, Brt.	
18	11 50 57	260 04	11 52 28	111 82	4 , 4	2	495b, Brt.	
22	13 41 1	283 00	13 41 16	54 07	4 , 4	3	495b, Brt.	
30	12 44 23	14 80	12 44 14	41 98	4 , 4	2	495b, Brt.	
Dec. 13	9 53 55	80 31	9 54 31	116 20	4 , 4	3	367b, Brt.	
28	8 43 45	313 37	8 45 17	34 14	4 , 4	3	495b, Brt.	
28	10 9 18	313 07	10 11 1	38 52	4 , 4	3–4	495b, Brt.	
1913 Jan. 14	9 47 48	71 04	9 48 30	93 80	4 , 4	2	495b, Brt.	
				Enceladus–Tethys				
1912 Oct. 1	14 20 17	112 39	14 20 17	63 96	4 , 4	3–4	495b, Brt.	
2	12 4 34	279 13	12 5 17	62 63	4 , 4	3	495p, Brt.	
2	13 42 28	272 45	13 43 27	65 18	4 , 4	3	495p, Brt.	
4	12 23 48	355 47	12 24 25	14 58	4 , 4	2	495p, Brt.	
4	14 43 0	317 83	14 43 50	20 15	4 , 4	3	495p, Brt.	
5	11 57 12	122 26	11 58 22	46 56	4 , 4	3	495p, Brt.	
10	12 11 42	268 16	12 12 49	73 99	4 , 4	3–4	495p, Brt.	
16	15 54 14	115 36	15 55 55	61 83	4 , 4	3	495p, Brt.	
26	11 55 10	79 05	11 56 30	85 23	4 , 4	4	367p, Brt.	
28	13 54 20	321 33	13 55 21	10 32	4 , 4	2	495p, Brt.	
Nov. 9	14 14 33	275 89	14 15 19	75 59	4 , 4	3–4	367p, Brt.	
18	13 7 5	65 85	13 8 23	29 05	4 , 4	2	495p, Brt.	
22	11 17 22	270 04	11 19 16	26 75	4 , 4	3	495p, Brt.	
30	10 46 11	258 16	10 17 21	85 33	4 , 4	2	367p, Brt.	
Dec. 9	10 28 27	358 90	10 28 29	31 55	4 , 4	3–4	367p, Brt.	
14	11 22 24	100 59	11 22 26	67 72	4 , 4	2	367p, Brt.	Haze.
20	7 49 42	71 66	7 51 22	75 84	4 , 4	3	367p, Brt.	
30	11 8 26	270 65	11 9 24	87 87	4 , 4	3–4	367p, Brt.	
1913 Jan. 4	9 25 19	73 78	9 25 22	77 47	4 , 4	3–4	367p, Brt.	
4	10 20 56	68 78	10 22 14	74 04	4 , 4	4	367p, Brt.	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
			Tethys–Dione					
	h m s	°	h m s	″				
1912 Oct. 1	14 42 17	71 31	14 43 44	27 66	4 , 4	3–4	495p, Brt.	
2	12 26 53	60 99	12 27 55	17 69	4 , 4	3	495p, Brt.	
2	14 3 37	53 48	14 4 22	17 87	4 , 4	3	495p, Brt.	
5	12 25 26	284 78	12 26 49	91 36	4 , 4	3	495p, Brt.	
7	11 51 24	7 88	11 51 45	48 71	4 , 4	4	495p, Brt.	
10	12 44 48	55 95	12 47 9	68 58	4 , 4	3	495p, Brt.	
10	14 24 14	43 51	14 25 1	58 44	4 , 4	2	495p, Brt.	
16	16 18 26	283 45	16 19 57	91 43	4 , 4	3	495p, Brt.	
26	12 19 52	82 83	12 20 29	14 03	4 , 4	4	367p, Brt.	
28	13 40 46	199 24	13 41 55	44 36	4 , 4	4	367p, Brt.	
Nov. 9	15 17 51	64 48	15 18 43	70 90	4 , 4	3	367p, Brt.	
20	13 12 46	79 11	13 14 9	42 49	4 , 4	2	495p, Brt.	
22	12 48 7	103 74	12 48 42	97 04	4 , 4	3	367p, Brt.	
29	14 1 41	268 09	14 2 53	110 30	4 , 4	3	495p, Brt.	Recorded as *Enceladus–Tethys*, with p differing [180°.
29	12 17 5	264 47	12 16 45	108 90	4 , 4	4	367p, Brt.	
30	10 46 8	99 63	10 48 0	74 06	4 , 4	2	367p, Brt.	
Dec. 13	11 31 59	196 74	11 32 7	18 12	4 , 4	3	495p, Brt.	
14	9 55 34	130 66	9 55 48	10 71	4 , 4	2–3	495p, Brt.	
19	8 50 4	109 89	8 50 25	38 17	4 , 4	3	367p, Brt.	
20	8 15 43	83 03	8 16 42	15 29	4 , 4	3–4	495p, Brt.	
1913 Jan. 15	8 16 38	266 96	8 17 22	86 95	4 , 4	2–3	367p, Brt.	
30	8 4 16	45 39	8 4 20	41 75	4 , 4	3	367p, Brt.	
Feb. 1	9 8 19	228 59	9 8 50	18 15	4 , 4	3	495p, Brt.	
			Tethys–Rhea					
1912 Oct. 1	15 6 45	91 26	15 7 40	40 86	4 , 4	3–4	495p, Brt.	
2	12 47 38	83 00	12 49 4	92 85	4 , 4	3–4	495p, Brt.	
2	14 24 28	79 85	14 25 37	95 86	4 , 4	3	495p, Brt.	
5	13 13 40	224 61	13 14 22	39 51	4 , 4	3	495p, Brt.	
7	12 22 43	317 61	12 23 10	48 34	4 , 4	4	495p, Brt.	
10	13 8 0	93 38	13 8 51	107 63	4 , 4	3	495p, Brt.	
10	14 43 0	90 13	14 44 48	105 05	4 , 4	2	495p, Brt.	
16	16 43 26	327 26	16 44 43	61 89	4 , 4	3	495p, Brt.	
26	12 45 42	270 50	12 46 36	125 87	4 , 4	4	367p, Brt.	
29	13 58 3	62 39	13 58 18	99 50	4 , 4	3	367p, Brt.	
Nov. 9	14 56 58	254 26	14 57 44	36 52	4 , 4	3	367p, Brt.	
20	14 11 57	97 84	14 13 35	120 27	4 , 4	2	367p, Brt.	
22	11 39 19	274 89	11 40 13	14 30	4 , 4	3	495p, Brt.	
29	12 40 58	109 72	12 42 17	47 83	4 , 4	4	495p, Brt.	
30	11 6 56	64 88	11 7 38	96.36	4 , 4	2	367p, Brt.	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
			Tethys–Rhea (Continued)					
	h m s	°	h m s	″				
1912 Dec. 14	9 7 32	307.90	9 8 34	66.12	4, 4	2	367p. Brt.	
19	8 21 25	340.34	8 21 51	40.38	4, 4	3	367p. Brt.	
27	10 33 35	20.23	10 35 28	47.08	4, 4	4	367p. Brt.	Windy.
1913 Jan. 4	7 47 24	138.55	7 48 3	35.52	4, 4	3	495p. Brt.	
21	10 10 1	236.79	10 10 46	83.54	4, 4	3–4	367p. Brt.	
30	8 25 29	258.73	8 26 11	70.86	4, 4	3	367p. Brt.	
			Titan–Hyperion					
1912 Oct. 15	15 7 54	208.171	15 9 5	186.55	4, 4	3	367b. Red	
15	15 42 49	207.321	15 44 56	184.67	4, 4	3	388, Red	
16	13 56 9	170.053	13 59 48	156.14	4, 4	2	367b. Red	
16	15 3 11	168.280	15 3 46	156.51	4, 4	2	367b. Red	
Nov. 18	14 20 29	66.304	14 20 59	209.27	4, 4	2	367b. Red	
20	13 44 29	7.529	13 44 13	126.97	4, 4	2	495b. Red	
Dec. 9	11 12 44	355.736	11 14 14	175.07	4, 4	3	367b. Red	
28	9 7 45	347.339	9 8 46	69.59	4, 4	2	495b. Red	
28	10 35 51	343.852	10 37 19	70.31	4, 4	3	495b. Red	Hyperion
30	10 2 46	287.961	10 3 5	129.60	4, 4	3	367b. Red	very faint.
30	10 34 4	287.719	10 34 47	130.28	4, 4	3	367b. Red	
1913 Jan. 4	8 19 41	254.155	8 20 17	88.21	4, 4	2	388, Red	
4	9 50 57	253.889	9 52 49	87.00	4, 4	1	388, Red	
14	10 24 33	197.390	10 26 4	89.63	4, 4	2	495b. Red	

Comp: t = transits. Seeing: 2 = good, 3 = fair, 4 = poor. Power and Illum.: b = occulting bar over planet, p = prism, Brt. = bright field, Red = red wires.

Clark II micrometer was used.

Value of one revolution = $9''.9329 + 0''.0000\,525\,(t^\circ - 50^\circ \text{F.}) + 0''.0255\,(1^{\text{m}}.280 - \text{focal scale})$.

U. S. Naval Observatory, Washington, D. C.,
1922, July 7.

CORRIGENDUM

In No. 805, page 118, for log. *e* read 9.814601 instead of 8.814601.

ERRATA IN DECLINATION CATALOGUE OF LEWIS BOSS,

U. S. Northern Boundary Commission

By R. H. TUCKER.

No. 8	Annual Variation should read	19″.9185
No. 138	Declination *probably* should read	33″.59
No. 251	Annual Variation should read	10″.2801
No. 259	Proper Motion should read	+0″.3408
No. 279	Declination should read	−10° 18′
No. 320	Right Ascension should read	$17^{\text{h}}\ 53^{\text{m}}$
No. 416	Declination should read	+38°
No. 481	Proper Motion should read	+0″.1283

Lick Observatory,
June 23, 1922.

OBSERVATIONS OF (944) 1920 HZ,

MADE WITH THE 24-INCH REFLECTOR OF THE YERKES OBSERVATORY,

By G. VAN BIESBROECK.

This asteroid, discovered 1920 Oct. 31 on photographs obtained at Bergedorf by BAADE, proved to be of unusual interest. Its orbit extending at aphelion as far as *Saturn's* with an inclination of 13° has a decided cometary character. Yet at no time did it show an appearance different from that of the other asteroids. I located the object by means of the excellent ephemerides published by RENAUX (*Ephemerides Marseilles* No. 555) and by VICK (*A. N.* 5144) for this years' opposition, at which time (April 2) the brightness was 17^{M}.

Well-measurable images were obtained here with the 24″ reflector, by moving the plate so as to follow the asteroid's motion. PAGET's "Hurricane" plates were used throughout. Exposures ranged from 18 to 60 min. I took some additional plates in May, but they no longer revealed the object and I found too late that the emulsion then used was of inferior quality.

In measuring I always referred the asteroid to three stars, the astrographic coördinates of which were taken from the Bordeaux zones +11° and +15°. On January 26, 28, and March 2, the plates were taken by MR. O. STRUVE. The other plates were exposed by myself and I made the measures and reductions.

On January 28, 1922, I observed the asteroid visually with the 40-inch refractor in the following position:

$$\text{Jan. 28, } 15^{h}\ 1^{m}\ 52^{s} \text{ G. M. T.} \quad \Delta\alpha = +10^{s}.79, \quad \Delta\delta = 21''.5.$$

relatively to Star Bord. ph. +14°, $13^{h}\ 28^{m}$, Nr. 150; whence;

$$\alpha \text{ app.} = 13^{h}\ 33^{m}\ 0^{s}.64 \quad \delta \text{ app.} = +13°\ 37'\ 38''.8.$$
$$9.318_{n} \qquad\qquad 0.644$$

I found the object too difficult for regular visual observations and did not try it again. The photographic positions are as follows:

1922	G. M. T.	1922.0 α	1922.0 δ	Aberration		Parallactic factors	
	h m s	h m s	° ′ ″	s	″		
Jan. 23	23 21 18	13 33 33.84	+13 37 19.5	+0.18	− 9.0	8.066	0.626
26	22 39 17	33 17.16	13 37 22.7	0.25	− 9.3	8.668*n*	0.627
27	23 24 8	33 8.68	13 37 32.6	0.27	− 9.4	8.676	0.627
28	22 26 0	32 59.51	13 37 50.1	0.29	− 9.5	8.760*n*	0.627
Feb. 3	22 5 23	31 31.63	13 40 46.1	0.15	−10.0	8.690*n*	0.626
3	23 3 53	31 33.84	13 40 47.9	0.45	−10.0	8.811	0.627
25	22 9 9	19 18.77	14 6 49.2	0.92	−10.5	9.168	0.628
27	21 43 26	18 17.31	14 9 16.1	0.96	−10.5	9.067	0.624
27	22 7 56	18 16.38	14 9 16.7	0.96	−10.5	9.211	0.630
Mar. 2	22 16 0	15 19.94	14 13 4.1	1.02	−10.4	9.305	0.635
3	22 25 11	14 58.64	14 14 14.1	1.03	−10.4	9.355	0.640
3	22 49 11	14 57.86	14 14 16.0	1.03	−10.4	9.424	0.649
8	22 56 15	13 10 31.77	14 19 21.5	1.11	−10.1	9.493	0.662
21	17 39 11	12 58 3.00	14 24 11.9	1.25	− 8.9	9.167*n*	0.624
21	18 10 14	58 1.70	14 24 11.7	1.25	− 8.9	8.947	0.618
Apr. 14	15 18 33	31 27.22	13 46 47.8	1.25	− 5.8	9.415*n*	0.639
14	15 50 57	31 25.92	13 46 42.2	1.25	− 5.8	9.240*n*	0.631
21	16 40 55	12 28 27.50	+13 22 55.2	+1.19	− 4.8	8.492	0.630

CONTENTS.

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COMPARISON OF STANDARD STAR SYSTEMS,

By R. H. TUCKER.

Incidental to a discussion of our meridian circle latitude results during the past quarter of a century, some comparisons of standard star declinations have been made. The first comparison tabulated is that between the old system of AUWERS, which was the basis for the original A. G. zones, and his new system, derived about 25 years later. Though the old system may be no longer in service, the relation of that system to the modern ones is of importance in discussing modern observations of the A. G. zone stars.

The new or revised system of AUWERS has been generally employed in the reduction of the Lick Observatory work. Conditions governing some schemes of observation, such as international coöperation for certain lists of stars, have made necessary some departures from this general practice.

AUWERS NEW SYSTEM — OLD SYSTEM, 1900

10° ZONES.

Decl.	Stars	Δ α	Δ P. M.	Δ δ	Δ P. M.
°		s	s	″	″
85.3	10	+0.006 sec. δ	+0.0003 sec. δ	+0.10	+0.010
74.9	51	+ 005	+ 4	+ 10	+ 8
65.0	54	+ 004	+ 6	+ 20	+ 8
55.6	58	+ 005	+ 6	+ 11	+ 3
44.8	61	+ 004	+ 9	+ 18	− 4
35.8	61	+ 011	+ 11	− 10	− 12
25.3	63	+ 013	+ 12	+ 09	− 1
15.5	59	+ 024	+ 12	− 04	− 11
+ 5.7	56	+ 027	+ 13	+ 05	− 8
− 4.9	50	+ 037	+ 15	+ 03	− 9
15.0	44	+ 030	+ 15	+ 31	− 8
24.9	32	+ 029	+ 11	+ 67	− 5
Sum	599				
Mean	(12)	+0.016 sec. δ	+0.0010 sec. δ	+0.14	(−0.003)
Average residual 10° zone				±0.13	

30° ZONES

Decl.	Stars	Δ α	Δ P. M.	Δ δ	Δ P. M.
°					
75	(3)	+0.005 sec. δ	+0.0004 sec. δ	+0.13	+0.009
45	(3)	+ 007	+ 9	+ 06	− 3
+15	(3)	+ 021	+ 12	+ 03	− 8
−15	(3)	+ 032	+ 15	+ 34	− 7

There is nearly uniform progression in $\Delta\alpha$ from the pole south to the limit of declinations, $-31°$. The proper-motions have a similar progressive increase, and would evidently account for $\Delta\alpha$ in a period of about twenty years, in most of the 10° zones.

A discontinuity occurs in $\Delta\delta$ at $+41°$, corresponding undoubtedly to a change in systematic errors at about the average latitude of the principal European observatories.* The change is approximately $0''.4$, as will be evident in the summation of individual differences in twelve groups of uniformly ten stars each.

DECL.	$\Delta\delta$	DECL.	$\Delta\delta$
49°.1	$+0''.27$	39°.4	$-0.''14$
47 .5	+ 21	38 .1	+ 01
45 .6	+ 25	37 .1	− 08
43 .6	+ 24	34 .5	− 12
41 .9	+ 25	33 .1	− 21
41 .0	− 14	31 .2	− 06

The discontinuity in declination has probably been eliminated in the modern systems. With declinations from the old system, there would be an average difference of $0''.3$ in the latitudes derived from the stars between $+30°$ and $+40°$, and those derived from stars between $+40°$ and $+50°$. In drawing conclusions from this and subsequent comparisons the new system of AUWERS will be used as a standard of reference, though the errors may actually be distributed partly in each system of declination. The total range of $\Delta\delta$ in 10° zones is over $0''.7$, and observed latitudes would have corresponding differences. In the hourly means of $\Delta\delta$ between $-31°$ and $+37°$ there is a range of $0''.4$, and latitudes derived from stars in that area would present corresponding deviations at different epochs of the year. The deviations in the observed latitudes at the four seasons can be illustrated by the summation of $\Delta\delta$ in groups of six hours each, between $-40°$ and $+40°$ declination.

0^h to 5^h	83 stars	$\Delta\delta = 0''.00$
6 to 11	66 stars	-0 .11
12 to 17	68 stars	$+0$ .03
18 to 23	72 stars	$+0$ .09

There would be a range of $0''.2$ in the latitudes observed at the four seasons, due to declination errors. In the single zone at $+25°$ the quarterly range is a maximum, and amounts to $0''.4$.

The mean differences of proper motion in declination have a progression from the pole to the equator. On the old system, latitudes derived from stars north of 50° would exhibit a progressive decrease of $0''.007$ per year, while latitudes derived from stars south of 50° would exhibit a progressive increase of $0''.007$ per year. In a quarter of a century the two combinations would give apparent changes in latitude of $0''.17$ each, in contrary directions. Differences of declination and of proper-motion are undoubtedly mainly due to errors in the older system. The errors in our modern systems are however not to be considered as negligible.

The average residuals of individual values of $\Delta\alpha$ and $\Delta\delta$ from the means of 10° zones, between $-30°$ and $+30°$, are $\pm 0^s.021$ in right ascension, and $\pm 0''.26$ in declination. Single residuals over $0^s.1 \sec\delta$ in right ascension, and over $1''.0$ in declination have not been included in these figures, and the corresponding values of $\Delta\alpha$ and $\Delta\delta$ have not been included in the means.

For latitudes derived from observations of the same circumpolar stars at both culminations the errors due to the adopted declinations can be eliminated from a series covering a full year. The results are however affected by certain classes of systematic error, and the same procedure has not successfully eliminated the errors of declination for our circumpolar stars, as will be evident in these comparisons.

The declination system of LEWIS BOSS, printed in 1879 in the *Report of the U. S. Northern Boundary Commission*, was undoubtedly the best treatment of declinations that had appeared up to that date. It was adopted in the *American Ephemeris* for some years, and was employed by NEWCOMB as an intermediate standard, with which to reduce his own normal system of declinations, a quarter of a century later. The computed correction to the N. B. S. declination system at the equator was $+0''.2$ in 1875, and $+0''.3$ for 1900. The $\Delta\delta$ has been carried forward to 1900, with the differential proper-motions for each 10° zone.

The computed differences between this early system and the recent *Preliminary General Catalogue* of the same author have been tabulated below.

If the declinations of the N.B.S. were still used, the latitudes derived from observations of these stars would exhibit a progressive decrease of $0''.005$ per year, or $0''.13$ in a quarter of a century. This conclusion of course is based upon the adoption of the proper-motions of AUWERS. Observed latitudes would exhibit a progressive decrease of $0''.003$ per year, by comparison with the proper motions of the P.G.C. The 10° zones for 1875 have a range of $0''.2$, and those of 1900 have a range of $0''.3$. The hourly means have an average residual of $\pm 0''.03$, and the range is nearly $0''.2$ for the epoch 1875. Combinations of six hours each.

*There is a discontinuity in BRADLEY's declinations near this point, which may account for part of the difference.

Auwers — Boss N. B. S.					Boss P. G. C. — N. B. S.	
Decl.	Stars	1875 Δ δ	Δ P. M.	1900 Δ δ	Decl.	1900 Δ δ
°		"	"	"	°	"
85.7	7	−0.04	+0.0026	+0.02	85	−0.06
74.2	22	+ 05	+ 50	+ 17	75	+ 15
64.9	22	+ 11	+ 62	+ 26	65	+ 21
55.7	35	+ 12	+ 60	+ 27	55	+ 22
45.4	39	+ 15	+ 37	+ 24	45	+ 11
35.4	33	+ 17	+ 62	+ 33	35	+ 11
25.7	39	+ 17	+ 66	+ 34	25	+ 12
15.0	30	+ 02	+ 27	+ 09	15	− 08
+ 6.3	28	+ 10	+ 60	+ 25	+ 5	+ 11
− 1.8	18	+ 01	+ 13	+ 01	− 5	− 05
15.2	10	+ 07	+ 77	+ 26	15	+ 16
25.8	10	+ 06	+ 83	+ 27	25	+ 23
Sum	293					
Mean	(12)	+0.08	+0.0052	+0.21	(12)	+0.11
Average residual		±0.05		±0.09		±0.08
°						
75	(3)	+0.04	+0.0016	+0.15		+0.11
45	(3)	+ 15	+ 53	+ 28		+ 16
+15	(3)	+ 10	+ 51	+ 23		+ 05
−15	(3)	+ 05	+ 58	+ 19		+ 11

0^h to 5^h	76 stars	$\Delta\delta = +0''.087$
6 to 11	57 stars	+ 091
12 to 17	76 stars	+ 124
18 to 23	85 stars	+ 116

The average residual of a single $\Delta\delta$ from the zone means is $\pm 0''.14$. The average residual of single proper-motion differences is $\pm 0''.0057$.

In the following comparison with Newcomb the differences of proper-motions have not been tabulated. The mean differences are quite insensible, and the average differences are $\pm 0^s.00035 = 0''.005$ in right ascension, and $\pm 0''.003$ in declination. The average residual of 10° zones is $\pm 0''.08$, and the range is $0''.25$. The hourly means of $\Delta\delta$ between −30° and +37° have an average residual of $\pm 0''.05$, and the range is close to $0''.3$. Combinations of six hours each.

0^h to 5^h	101 stars	$\Delta\delta = -0''.16$
6 to 11	86 stars	− 11
12 to 17	87 stars	− 15
18 to 23	98 stars	− 09

The average residuals of single differences from the zone means are $\pm 0^s.013$ in right ascension, and $\pm 0''.15$ in declination.

A comparison between Auwers and Boss for the epoch 1910 was published by Benjamin Boss in No. 615 of the *Astronomical Journal*. It is in essential agreement with the comparison printed in No. 323 of our *Bulletins*, for a limited number of stars. Our *Bulletin* also included a comparison with Newcomb, for the same stars. The comparison made by Mr. Boss has been arranged here to conform to the other tables. The 10° zones have an average residual of $\pm 0''.05$, and the range is $0''.20$. The average residual of hourly means of $\Delta\delta$ between −20° and +30° is $\pm 0''.05$, and the range is over $0''.2$. Combinations of six hours each.

0^h to 5^h	$\Delta\delta = +0''.07$
6 to 11	+ 19
12 to 17	+ 20
18 to 23	+ 19

The average residuals for single stars, as given in our *Bulletin*, are $\pm 0^s.010$ in right ascension, and $\pm 0''.09$ in

declination, for the area between −31° and +37° declination. The mean difference of proper-motions in declination is 0″.002 per year. Compared with the proper-motions of AUWERS those of BOSS would produce a decrease of 0″.05 in the observed latitudes, in a quarter of a century.

		AUWERS − NEWCOMB, 1900		AUWERS − BOSS P. G. C., 1910	
Decl.	Stars	Δα	Δδ	Δα	Δδ
°		s	″	s	″
85.2	10	+0.001 sec. δ	−0.01	−0.001 sec. δ	+0.10
74.8	50	− 012	+ 02	− 008	+ 04
64.9	53	− 012	+ 01	− 006	+ 01
55.0	58	− 019	− 20	− 001	+ 07
44.9	62	− 015	− 14	+ 005	+ 12
35.0	60	− 006	− 04	+ 003	+ 21
25.3	63	− 007	− 03	+ 002	+ 21
15.0	60	− 005	− 10	000	+ 19
5.7	56	− 004	− 18	000	+ 13
4.9	54	− 003	− 23	000	+ 11
15.2	51	+ 005	− 22	003	+ 12
25.4	51	+ 004	− 25	007	+ 06
Sum	628				
Mean	12[illegible]	−0.006	−0.10	0.003	+0.12
Average residual 10° zone			±0.08		±0.05
75	3	−0.007	0.00	−0.006	+0.06
55	[illegible]	013	− 13	+ 002	+ 14
[illegible]	3	− 005	− 10	+ 004	+ 19
	3	+ 002	− 17	− 007	+ 10

Some conclusions may be drawn as to the respective precision of the catalogues which have been compared. The probable errors for single stars, each with respect to its own system, have been estimated as follows, and the corresponding weights have been assigned.

	R. A.	DECL.	WT.
[illegible] System	±0.017	±0″.21	1
[illegible]	. . .	0 .10	5
[illegible] System	0 .006	0 .07	10
Boss P.G.C.	0 .007	0 .07	10
[illegible]	0 .010	0 .10	5

These accidental errors of position at the catalogue epochs may be nearly doubled in the course of a quarter of a century, from the effect of proper-motion. The probable error of proper-motion in the modern catalogues may be estimated to be ±0″.003 in each coordinate, or ±0″.004 per star.

The modern declination systems have average deviations of ±0″.05 in the 10° zones, and the range is nearly 0″.2. The hourly deviation in the area most in use is ±0″.03, with a range of nearly 0″.2. This last class of periodic error, varying with right ascension, can be eliminated in latitude results, by observing two groups of stars each night, and closing the cycle of groups in a year. A further advantage in meridian circle work is the elimination of some classes of systematic error, such as that due to graduation errors. This device, employed in fundamental work, has not however eliminated the errors of declination in our standard star places.

In addition to the above errors, which may be classed as accidental, there are certain systematic errors which are difficult to ascertain. From the identity of the greater part of the data, and from the similarity of methods of treatment, it is most likely that the systematic errors of all our standards are nearly the same. They are quite likely to be as large as the accidental errors, of which we can form an estimate by comparison of two authorities.

From our own results of observation the correction to AUWERS system at the equator is approximately

+0″.3. His declination system is between those of Boss and Newcomb. The resulting correction to Boss at the equator would be +0″.4, and that of Newcomb +0″.4.

Leid. Observatory,
July 11, 1922.

OBSERVATIONS OF COMET *SKJELLERUP b* 1922,

MADE WITH THE 40-INCH AND 12-INCH REFRACTORS AND THE 24-INCH REFLECTOR OF THE YERKES OBSERVATORY,

By G. VAN BIESBROECK.

Date	G. M. T.	Δα	Δδ	Cp.	App. α	App. δ	Log pΔ		★	Instr.
1922	h m s	m s	′ ″		h m s	° ′ ″				
May 24	15 15 24	+0 4.34	+0 17.4	6 , 6	8 15 56.19	+23 32 18.6	9.659	0.679	1	40
26	15 50 20	−0 1.81	+3 46.9	6 , 6	8 45 50.97	28 50 28.0	9.688	0.674	2	40
27	15 17 50	+0 11.66	−1 34.5	6 , 6	8 52 30.17	29 57 12.4	9.678	0.620	3	12
28	16 49 24	−0 15.29	−2 52.8	6 , 6	8 59 56.60	31 9 32.3	9.703	0.689	4	12
29	15 15 5	+2 1.57	−9 26.4	15 , 3	9 7 5.97	32 17 12.9	9.683	0.584	5	12
June 11	15 34 44	−0 33.64	+9 18.9	6 , 6	11 25 34.89	46 13 7.2	9.697	0.099	6	40
18	17 47 5	+2 57.36	+1 40.8	20 , 4	13 5 32.26	48 28 30.8	9.782	0.323	7	40
21	15 7 15	+5 22.26	+3 28.9	20 , 4	13 44 1.42	47 52 7.4	9.404	9.656*n*	8	40
23	16 37 41	−4 22.08	+5 20.0	20 , 4	14 9 44.71	47 0 22.2	9.612	9.614	9	12
24	15 37 40	+0 16.05	+1 49.2	6 , 6	14 20 9.90	46 30 14.1	9.394	9.100*n*	10	12
28	15 36 24	−0 20.28	−2 51.9	6 , 6	15 0 43.03	43 56 14.1	9.240	7.672*n*	11	40
July 2	19 2 32	+3 10.08	+0 51.4	20 , 4	15 34 26.59	40 17 41.2	9.744	0.419	12	40
12	15 59 4	+2 11.89	+8 53.2	20 , 4	16 30 17.66	33 3 12.1	9.093	0.184	13	40
18	15 8 34	−0 13.64	+1 59.4	6 , 6	16 53 23.88	28 43 15.6	8.072	0.317	14	40
23	15 34 32	+0 44.34	+1 59.8	6 , 6	17 9 8.88	25 22 39.1	8.830	0.414	15	40

Comparison Stars

No.	α (1922.0)	δ (1922.0)	Red. α	Red. δ	Authority
	h m s	° ′ ″	s	″	
1	8 15 51.26	+23 32 10.6	+0.59	− 9.1	Par. ph. 23°, 8h 12m No. 249; 24°, 8h 16m No. 75
2	8 45 52.16	28 46 48.1	0.62	− 7.0	Oxf. ph. 28° 26332, 29° 26178
3	8 52 17.88	29 58 53.1	0.63	− 6.5	Oxf. ph. 30° 22520, 31° 22713
4	9 0 11.25	31 12 31.0	0.64	− 5.9	Oxf. ph. 31° 22980.
5	9 5 3.76	32 26 44.8	0.64	− 5.5	A. G. *Lei.* 3777
6	11 26 7.65	46 3 45.2	0.88	+ 3.4	*Hels.* ph. Cliché 180 No. 62 = 187 No. 8
7	13 2 33.65	48 26 42.6	1.25	+ 7.4	A. G. *Bo.* 8807 (verbess.)
8	13 38 40.74	47 48 29.8	1.42	+ 8.7	A. G. *Be.* 9082 (verbess.)
9	14 13 32.20	46 54 52.4	1.62	+ 9.8	A. G. *Bo.* 9355 (verbess.)
10	14 19 52.20	46 28 15.2	1.65	+10.0	A. G. *Bo.* 9412 (verbess.)
11	15 1 1.43	43 58 54.8	1.88	+11.2	A. G. *Bo.* 9762 (verbess.)
12	15 31 14.17	40 16 34.7	2.04	+12.1	A. G. *Bo.* 10032 (verbess.)
13	16 27 33.44	32 54 34.8	2.33	+14.1	A. G. *Lei.* 5820
14	16 53 35.02	28 41 31.4	2.47	+15.4	Oxf. ph. 28° 13305
15	17 8 55.02	25 20 23.6	2.52	+16.0	A. G. *Cbr. E* 8063

Photographic positions obtained with the 24-inch reflector

1922	G. M. T.	App. α	App. δ	log pΔ		Cp. stars
	h m	h m s	° ′ ″			
July 19	18 53 27	16 57 11.87	+27 55 58.8	9.616	0.558	Oxf. ph. 28°, 13526, 13528, 13548
19	19 27 27	16 57 20.19	27 55 3.1	9.652	0.603	
26	17 51 26	17 17 39.23	23 26 32.5	9.516	0.553	Par. ph. 21°, 17^h 20^m, Nos. 306, 322, 327
26	18 23 19	17 11.82	23 25 52.5	9.555	0.575	
Aug. 12	14 57 28	55 3.61	14 32 19.1	8.784	0.615	Bord. ph. 11°, 17^h 52^m, Nos. 257, 275, 294
12	15 36 20	55 6.18	14 31 31.0	9.130	0.621	
13	14 18 50	56 57.28	11 5 33.9	8.680	0.620	Bord. ph. 11°, 17^h 52^m, Nos. 328, 345, 355
13	15 15 17	17 57 1.52	11 4 26.3	9.190	0.630	
18	14 42 22	18 6 11.14	11 58 23.2	8.714	0.649	Kü 8029, Lpz. 6453, 6450

REMARKS

May 21. Total magnitude 12^m. Nucleus 13^m.5, about 5″ in diameter. The elliptic nebulosity extends about 10″ from the nucleus towards 265°, in the opposite direction only 10″.

June 11. Total magnitude 14^m. Nucleus 15^m and very diffuse. The rising moon makes the settings difficult.

July 18. Total magnitude 15. Sky good.

July 23. Total magnitude 15. Nebulosity about 15″ in diameter with 16^m central nucleus.

Aug. 13. The first plate was exposed by Mr. O. Struve, the second by Miss H. Bigelow.

Aug. 18. The central condensation is only faintly noticeable on the plate. Total brightness 16^m. Nucleus if any only 17^m.5. Exposure time, 50 min.

Williams Bay, Wis.
Sept. 22.

STAR FIELDS FOR THE 1923 AND 1925 ECLIPSES OF THE *SUN*,

By FREDERICK SLOCUM.

Whatever the outcome of the observations to test the Einstein Theory during the solar eclipse of September 20, 1922, it will undoubtedly be desirable to repeat the observations at the time of the next two or three eclipses.

The location of the eclipse of September 10, 1923 will be especially favorable for American astronomers. In southern California and northern Mexico the eclipse occurs near noon, the altitude of the *Sun* will be over 60° and totality will last about 3½ minutes. The star field, however, is very poor. Plate I shows all the stars of magnitude 9.0 or brighter, on the *B. D.* scale, within about 2° of the *Sun*. The dotted circle is drawn from the center of the *Sun* with a radius of 1°. The position of the *Sun's* axis is shown and also the probable extension of the corona with an exposure long enough to show 9th magnitude stars.

Table 1 gives the data for the stars plotted on the plate. The magnitudes are from the *B. D.* Only two stars, Nos. 1 and 37 are brighter than 8.0. No. 11 is included because photographically it is at least half a magnitude brighter than neighboring 9th magnitude stars, although the *B. D.* magnitude is 9.2 and the *H. P.* 9.7. No. 37 is σ *Leonis* and No. 36 is *N.G.C.* 3640, which may be mistaken for a comet during the eclipse.

The theoretical displacements in the last column are computed on the basis of a displacement of 1.75″ at the *Sun's* limb, in accordance with the Einstein Theory. The field shown on Plate I is 3.4° by 4.3° and would cover a plate 8 by 10 inches on a telescope of about 11.5 feet focal length. From Table 1 it will be noticed that even the most remote stars should show a displacement of .20″. The stars with very large displacements, Nos. 19, 20, 22, 24 will probably be cut out by the corona. From the remaining stars only the differential Einstein effect can be derived if the plate constants are to be obtained from the same stars. If, however, the constants can be determined independently, then the full displacement of each star can be measured.

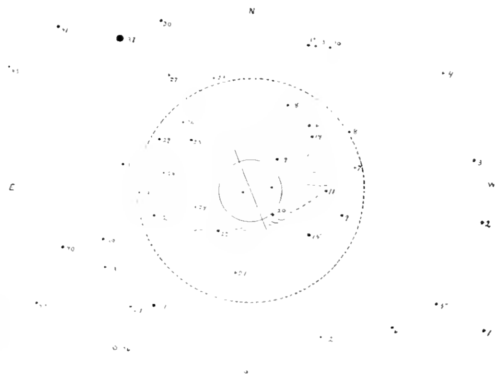
Various methods for doing this have been suggested.

TABLE 1

Star Field for the 1923 Eclipse of the *Sun*

No.	B.D. Number	Magnitude	Distance	Displacement
			′	″
1	+4.2423	7.7	141	0.20
2	5.2450	8.0	124	.22
3	5.2451	8.5	118	.23
4	6.2409	8.8	118	.23
5	4.2426	8.2	114	.24
6	4.2434	8.2	104	.27
7	5.2461	9.0	56	.50
8	6.2418	8.5	62	.45
9	5.2463	8.5	50	.56
10	6.2419	8.5	87	.32
11	5.2464	9.2	40	.70
12	4.2439	8.5	86	.33
13	6.2420	8.5	84	.33
14	5.2466	8.8	44	.63
15	5.2467	8.0	40	.70
16	6.2421	8.3	46	.61
17	6.2422	8.0	81	.33
18	6.2425	8.5	50	.56
19	5.2468	8.4	22	1.27
20	5.2469	8.0	17	1.64
21	4.2443	9.0	44	.63
22	5.2474	8.0	27.5	1.04
23	6.2427	8.8	61	.46
24	5.2475	9.0	30	.93
25	5.2476	8.5	42	.66
26	6.2429	8.8	51	.55
27	6.2432	8.9	75	.37
28	5.2478	9.0	46	.61
29	5.2480	8.5	55	.51
30	6.2433	8.9	103	.27
31	4.2449	8.0	79	.35
32	5.2481	8.5	52	.54
33	5.2483	9.0	58	.48
34	4.2450	8.8	89	.31
35	5.2484	8.2	69	.40
36	4.2451	Neb.	114	.25
37	6.2437	4.3	107	.26
38	4.2452	8.5	87	.33
39	5.2487	8.4	81	.35
40	4.2454	8.3	105	.26
41	6.2443	8.7	135	.21
42	4.2455	8.8	128	.21
43	6.2448	8.4	146	.19

PLATE I



Star Field for the 1923 Eclipse of the *Sun*

Plates may be exposed on a comparison field the night before and the night after the eclipse. Plates may be exposed to the eclipse field some months before the eclipse, left undeveloped and then exposed to the same field during the eclipse. Another suggestion is to expose on the eclipse field during the eclipse and then turn quickly to a selected comparison field of bright stars near by, and, with a short exposure, secure enough stars, unaffected by gravitational displacement, to furnish an accurate determination of the scale value and other plate constants.

All three of these methods may be tried during the Australian eclipse, and the experience at this time may suggest the best procedure for next year. Then it will remain only to determine the exposure time necessary to get the desired stars with the apparatus available.

Interest in the 1925 eclipse lies chiefly in the fact that the path of totality passes over several observatories. The eclipse occurs on January 24, begins at sunrise in the Great Lake region, passes southeasterly over southern New England and thence across the Atlantic Ocean, but not quite to the European shore. The Vassar, Yale, Van Vleck, and Nantucket observatories are within the path.

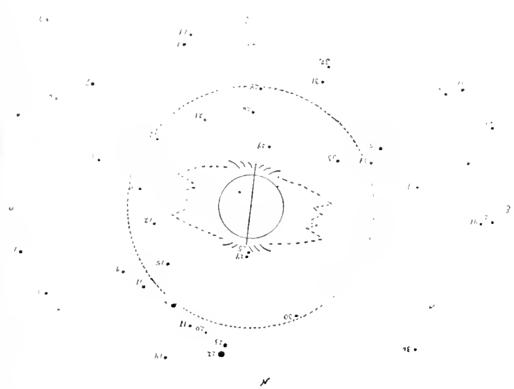
TABLE 2

STAR FIELD FOR THE 1925 ECLIPSE OF THE *Sun*

No.	B.D. Number	Magnitude	Distance	Displacement
			′	″
1	−19.5796	8.4	110	0.26
2	20.5913	8.5	118	.25
3	18.5660	7.5	105	.27
4	20.5917	8.5	131	.22
5	18.5663	8.7	103	.27
6	20.5919	8.9	104	.27
7	20.5926	8.7	91	.30
8	19.5809	7.0	75	.38
9	18.5680	8.0	66	.43
10	19.5813	7.7	53	.54
11	18.5681	8.3	61	.45
12	19.5815	8.9	16	.62
13	20.5935	8.7	51	.53
14	18.5684	8.5	84	.34
15	19.5817	8.8	18	.59
16	18.5685	5.1	61	.47
17	18.5686	8.8	64	.45
18	20.5941	8.5	81	.34
19	20.5942	8.8	86	.34
20	18.5688	8.9	64	.45
21	20.5945	9.0	16	.62
22	18.5689	5.1	72	.40
23	18.5694	7.3	69	.41
24	19.5830	8.3	25	1.44
25	19.5831	7.1	25	1.41
26	20.5954	8.8	46	.62
27	20.5955	9.0	78	.37
28	20.5956	8.8	56	.51
29	19.5835	8.7	29	.98
30	18.5705	8.2	57	.50
31	20.5963	9.0	68	.42
32	20.5966	9.0	75	.38
33	19.5846	8.5	16	.62
34	19.5850	8.2	61	.47
35	18.5852	7.8	67	.43
36	18.5714	8.5	105	.27
37	19.5864	8.5	84	.36
38	20.5984	9.0	106	.27
39	20.5986	8.5	116	.25
40	19.5867	9.0	107	.27
41	19.5868	8.9	111	.26
42	19.5870	8.7	116	.25
43	20.5994	9.0	122	.24

The eclipse occurs in Connecticut about 9 A. M. Local Mean Time and totality lasts about 90 seconds. The altitude of the *Sun* will be a little less than 20°. The star field is not as good as that of 1919, but better than the 1923 field. This advantage may be more than offset by the lower altitude of the field.

PLATE II



Star Field for the 1925 Eclipse of the *Sun*

Plate II shows the distribution of the stars. Nos. 8, 10, 16, 22, 23, 25, and 35 are brighter than magnitude 8.0. Of this group the theoretical displacement of No. 25 is 1.41″, while the others range from .38″ to .54″.

The data for all the stars of Magnitude 9.0 or brighter are given in Table 2.

Van Vleck Observatory,
August 12, 1922.

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MEASURES OF DOUBLE STARS MADE WITH THE 10½-INCH REFRACTOR OF THE UNIVERSITY OF MINNESOTA,

By F. P. LEAVENWORTH.

These observations are a continuation of the measures published in *A. J.* No. 787, and are in general repetition of measures of well known binaries. The right ascensions and declinations are for 1900, and the magnifying power 400.

10 Σ 3063 $0^h 2^m$ $-5° 6'$

	°	″			
1920.869	215.1	1.53	8.5	10.5	
.875	217.0	1.69	8.5	10.0	
1920.87	216.0	1.61	8.5	10.2	2*n*

32 O. Stone 1 $0^h 1^m$ $-14° 44'$

1920.845	109.2	9.41	8.4	8.6	
.853	108.0	9.47	8.6	8.5	(1)
1920.85	108.6	9.44	8.5	8.6	2*n*

151 A. Clark 1 $0^h 16^m$ $+32° 25'$

1921.830	284.4	1.34	8.2	8.8	
21.913	287.3	1.27	8.0	9.5	
22.025	285.1	1.33	7.5	8.5	(2)
1921.92	285.6	1.31	7.9	8.9	3*n*

260 OΣ 12 $0^h 26^m$ $+53° 59'$

1920.930	161.0	0.59	5.5	5.7	
21.020	158.3	0.60			
21.069	159.7	0.59	5.5	5.8	(3)
1921.01	159.7	0.59	5.5	5.8	3*n*

426 Σ 60 $0^h 43^m$ $+57° 18'$

1919.998	257.0	7.31	..	..	
21.069	259.0	7.09	4.0	7.5	(4)
21.075	258.5	7.41	3.5	7.0	
1920.71	258.2	7.27	3.8	7.3	3*n*

479 OΣ 20 $0^h 49^m$ $+18° 39'$

1920.845	300.6	0.50	..	..	
.875	299.3	0.65	6.0	6.8	
1920.86	299.9	0.58	6.0	6.8	2*n*

482 Σ 73 $0^h 50^m$ $+23° 5'$

1921.855	53.8	0.73	6.0	6.3	
21.885	55.4	0.65	..		
21.913	53.5	..			
22.025	56.0	0.73	6.0	6.3	(5)
1921.92	54.7	0.70	6.0	6.3	4-3*n*

591 Σ 91 $1^h 2^m$ $-2° 15'$

1920.853	318.5	4.05	7.3	8.0	
.894	320.8	3.88	7.0	7.7	
.960	320.0	3.88	7.0	7.9	(6)
1920.90	319.8	3.94	7.1	7.9	3*n*

1061 Σ 202 $1^h 57^m$ $+2° 17'$

1920.960	310.4	2.62	3.0	4.3	
21.034	312.3	2.37	3.0	3.8	
21.061	311.3	2.41	3.0	4.5	
22.030	309.7	2.45	3.0	4.2	
22.036	309.5	2.50	3.0	4.3	
22.041	309.7	2.55	3.0	4.2	
22.044	310.0	2.51	3.0	4.2	
1921.02	311.3	2.47	3.0	4.2	3*n*
1922.04	309.7	2.50	3.0	4.2	4*n*

1070 OΣ 38 $1^h 58^m$ $+41° 51'$

1921.061	109.4	0.55	..	...	
105	108.4	0.58	5.0	6.5	(7)
1921.08	108.9	0.56	5.0	6.5	2*n*

1262 Σ 262 $2^h 21^m$ $+66° 57'$

A and *B*

1921.105	251.3	2.04	..	..	
143	249.0	2.21	..		
157	249.6	2.26			
.206	249.2	2.43			
1921.15	249.8	2.24			4*n*

A and *C*

1921.105	110.1	7.39			
.143	109.3	7.10	..	..	
157	108.8	7.08	..	..	
206	111.5	7.10			
1921.15	109.9	7.17	..	..	1*n*

1365 OΣ 43 $2^h 35^m$ $+26° 11'$

1920.934	34.6	1.09	7.0	9.0	
21.021	35.3	1.04	7.0	8.7	
1920.98	35.0	1.06	7.0	8.8	2*n*

1401 Σ 299 $2^h 38^m$ $+2° 49'$

1920.930	290.6	3.00	..		
.935	291.3	2.84	..	..	
1920.93	290.9	2.92		..	2*n*

1427 Σ 305 $2^h 42^m$ $+18° 57'$

1922.014	313.4	3.06	7.3	8.1	
017	313.1	3.13	7.3	7.7	
077	314.1	3.20	7.3	7.8	(8)
1922.04	313.4	3.13	7.3	7.9	3*n*

1512 Σ 333 $2^h 53^m$ $+20° 57'$

1922.041	205.7	1.46	6.0	6.8	
.077	202.6	1.25	6.0	6.7	
134	203.3	1.22	6.0	6.4	(9)
1922.08	203.9	1.31	6.0	6.6	3*n*

1623 Σ 367 $3^h 9^m$ $+0° 22'$

1921.023	195.9	0.67		..	
.058	191.2	0.59		..	(10)
1921.04	193.6	0.63		..	2*n*

1900 OΣ 65 $3^h 44^m$ $-25° 17'$

1922.110	207.0	0.59			
.114	206.8	0.57	6.0	7.0	
1922.11	206.9	0.58	6.0	7.0	2*n*

2102 Σ 516 $4^h 10^m$ $-10° 30'$

1921.121	146.6	6.39	6.0	8.5	
.124	147.2	6.29	6.5	9.0	
179	147.2	6.07	6.0	8.0	
22.110	146.9	6.18	6.0	9.0	
126	148.7	6.14	6.0	8.7	(11)
1921.14	147.0	6.25	6.2	8.5	3*n*
1922.12	147.8	6.46	6.0	8.8	2*n*

2230 Σ 554 $4^h\ 24^m$ +15° 26′

1919.110	32.0	0.82	6.5	8.7	
19.131	28.4	0.78	6.5	8.8	
19.175	30.0				
19.184	29.2	0.80	6.5	8.5	
21.105	28.5	1.02	6.0	8.5	
21.138	28.6	0.85	6.5	8.8	
21.209	28.6	0.93			(12)
1919.15	29.8	0.80	6.5	8.7	4-3n
1921.15	28.6	0.93	6.2	8.6	3n

2443 Σ 622 $4^h\ 53^m$ +1° 31′

1921.034	169.5	2.31	7.8	8.0	
.132	169.8	2.35	8.0	8.1	(13)
1921.08	169.6	2.33	7.9	8.0	2n

2535 OΣ 98 $5^h\ 2^m$ +8° 22′

1921.064	139.7	1.01			
.099	138.6	0.92	6.0	7.0	
.105	139.9	1.04	6.0	7.3	
1921.09	139.4	0.99	6.0	7.2	3n

Jos 793 $5^h\ 4^m$ +10° 46′

1921.099	163.7	3.68	8.0	10.7	
.105	164.9	3.30	8.3	10.5	
.121	165.5	3.42	8.5	10.5	
1921.11	164.7	3.47	8.3	10.6	3n

2712 Da 5 $5^h\ 19^m$ −2° 29′

1922.044	79.4	1.43	4.0	5.0	
.055	82.8	1.42	4.0	5.5	
.077	79.0	1.37		..	(13)
1922.06	80.4	1.41	4.0	5.2	3n

2845 Σ 749 $5^h\ 31^m$ +26° 52′

1921.053	166.3	0.98			
21.099	165.2	1.05	7.0	7.1	
21.105	165.3	1.05	7.1	7.0	
22.131	163.6	1.01			
22.164	164.2	0.94	6.7	6.8	
1921.09	165.6	1.03	7.0	7.0	3n
1922.15	163.9	0.98	6.7	6.8	2n

2902 Σ 774 $5^h\ 36^m$ −2° 00′

1921.143	157.2	2.57	2.0	5.0	
21.146	157.0	2.50	2.0	6.0	
21.253	157.0	2.29	2.0	4.5	
22.285	157.9	2.66	2.5	5.0	(14)
1921.45	157.3	2.50	2.1	5.1	4n

Rumker 4 $6^h\ 14^m$ +21° 43′

1921.053	273.4	6.17	8.8	9.6	
.121	271.3	5.94	8.8	9.2	
.124	269.9	6.48	9.0	9.4	
1921.10	271.5	6.20	8.9	9.4	3n

3460 Σ 932 $6^h\ 29^m$ +14° 50′

1921.053	324.3	2.02	8.2	8.4	
.132	324.6	1.84	7.7	7.8	(15)
1921.09	324.4	1.93	8.0	8.1	2n

3559 Σ 948 $6^h\ 37^m$ +59° 33′

A and *B*

1921.173	108.7	1.52	5.0	5.6	
.179	109.1	1.60	5.0	5.7	
1921.18	108.9	1.56	5.0	5.6	2n

A and *C*

1921.173	305.5	8.62		7.0	
.179	306.9	8.61		6.5	
1921.18	306.2	8.62		6.8	2n

3596 *Sirius* $6^h\ 41^m$ −16° 35′

1921.058	66.6	11.13			
.064	64.7	11.32			
.069	66.4	11.28		8.0	
.099	67.9	11.52			
.105	65.9	11.24		7.0	
.132	67.0	11.30		7.0	
1921.09	66.4	11.30	.	7.3	6n

4122 *Castor* $7^h\ 28^m$ +32° 6′

A and *B*

1921.280	215.8	4.96	3.0	4.5	
.288	215.5	4.99	3.0	4.2	
.297	215.9	4.86	3.0	4.0	
.299	215.5	4.89	3.0	4.2	
1921.29	215.7	4.93	3.0	4.2	4n

A and *C*

1921.256	164.5	73.23	..	8.5	
.299	163.8	73.17	..	8.7	
1921.28	164.1	73.20		8.6	2n

4477 ζ *Cancri* $8^h\ 6^m$ +17° 57′

A and *B*

1921.204	275.2	0.76	5.0	5.6	
21.250	273.6	0.73	5.0	5.7	
21.272	273.1	0.72	5.0	5.7	
21.275	274.0	0.71	5.0	5.2	
22.164	264.2	0.82		...	
22.258	265.0	0.75	5.0	5.5	
22.266	264.8	0.73	5.0	5.5	
22.277	263.5	0.83	5.0	5.4	
1921.25	274.0	0.73	5.0	5.6	4n
1922.24	264.4	0.78	5.0	5.5	4n

AB and *C*

1921.204	109.0	5.48		6.3	
21.250	110.2	5.49	..	..	
21.256	109.6	5.54		.	
21.275	108.9	5.71		5.7	
22.164	108.1	5.65			
22.258	107.8	5.73		5.6	
22.277	107.8	5.55		6.0	
1921.25	109.4	5.56		6.0	4n
1922.23	107.9	5.64		5.8	3n

4771 Σ 1273 $8^h\ 41^m$ +6° 47′

AB and *C*

1921.256	244.5	3.26	.		
21.280	245.8	3.35	3.0	7.0	
21.313	245.6	3.25	3.0	7.0	
22.307	245.8	3.07			
22.320	245.0	3.21	3.0	7.0	
22.326	245.4	3.13	3.0	6.5	
1921.28	245.3	3.29	3.0	7.0	3n
1922.32	245.3	3.14	3.0	6.8	3n

5030 Σ 1338 $9^h\ 15^m$ +38° 37′

1920.267	183.4	1.46	7.0	7.3	
20.284	181.0	1.40	7.0	7.3	
20.284	181.2	1.40	7.0	7.3	
22.255	184.2	1.44	7.0	7.2	
22.258	184.0	1.56	7.0	7.5	
22.293	183.1	1.73	7.0	7.3	
1920.28	181.8	1.42	7.0	7.3	3n
1922.27	183.8	1.58	7.0	7.3	3n

5103 Σ 1356 $9^h\ 23^m$ +9° 30′

1921.275	129.4	1.06	6.0	7.0	
21.294	128.4	0.92	6.0	6.7	
21.313	129.6	0.94	6.0	6.8	
22.277	131.5	1.17	6.0	7.0	
22.307	129.7	1.02	6.0	6.7	
22.320	131.7	1.04	6.0	7.0	(16)
1921.29	129.1	0.97	6.0	6.8	3n
1922.30	131.0	1.08	6.0	6.9	3n

5235 A. C. 5 $9^h\ 48^m$ −7° 38′

1920.259	61.2	0.65	5.0	5.0	
21.275	59.6	0.59	5.0	5.5	
21.324	59.4	0.65	5.5	5.8	
21.335	60.3	0.61	5.0	5.5	
21.340	60.2	0.61	5.0	5.6	
22.307	56.4	0.61	6.0	6.5	
22.320	55.2	0.63	5.0	5.3	
22.326	58.2	0.62	5.0	5.6	(17)
1920.26	61.2	0.65	5.0	5.0	1n
21.32	59.9	0.62	5.1	5.6	4n
22.32	56.6	0.62	5.3	5.8	3n

5365 OΣ 215 $10^h\ 11^m$ +18° 14′

1921.313	199.6	1.03	7.0	7.2	
21.324	200.7	0.92	7.0	7.4	
21.327	199.8	1.10	7.0	7.3	
21.332	198.7	1.00	7.0	7.2	
22.255	199.5	1.04	7.0	7.2	
22.258	200.0	0.94	7.0	7.3	(18)
1921.32	199.7	1.01	7.0	7.3	4n
1922.26	199.8	0.99	7.0	7.2	2n

5388 Σ 1424 $10^h\ 14^m$ +20° 21′

1921.321	118.1	3.71	2.0	3.0	
.327	118.4	3.81	2.0	3.5	
.335	118.1	3.73	2.0	2.8	
.340	118.4	3.90	2.0	3.2	
1921.33	118.2	3.80	2.0	3.1	

5508 Σ 1457 $10^{h}\,34^{m}$ +6° 14′

1920.338	324.5	1.42	8.0	8.5	
21.272	321.5	1.56	7.6	7.7	
21.294	322.0	1.38	7.5	8.0	
21.299	323.0	.	.	.	
22.258	322.9	1.46	8.3	8.6	
22.266	322.5	1.56	8.0	8.2	
22.307	323.6	1.70	8.0	8.5	(19)
1921.05	322.7	1.45	7.7	8.1	4-3n
1922.28	323.0	1.57	8.1	8.4	3

5734 Σ 1523 $11^{h}\,13^{m}$ +32° 6′

1921.340	101.8	2.67	4.0	4.5	
.343	101.0	2.75	4.0	4.7	
316	100.9	2.62	4.0	4.4	
.406	101.9	2.70	4.0	4.5	
.447	101.4	2.77	4.0	4.8	
1921.38	101.4	2.70	4.0	4.5	5n

5765 Σ 1536 $11^{h}\,19^{m}$ +11° 5′

1921.343	35.1	1.81	1.0	7.0	
.346	34.6	1.79	4.0	7.0	
.349	35.4	1.76	4.0	7.0	
.370	37.1	1.82			(20)
1921.35	35.6	1.80	4.0	7.0	(4n)

6013 Σ 1593 $11^{h}\,58^{m}$ −1° 54′

1922.255	17.8	1.16	8.3	8.4	
.266	16.7	1.13	8.0	8.1	
1922.26	17.2	1.14	8.2	8.3	2n

6158 Σ 1639 $12^{h}\,19^{m}$ +26° 8′

1921.297	337.9	0.78	7.0	8.0	
21.406	339.5	0.84	7.0	8.0	
22.268	337.0	0.99	7.0	8.0	
22.304	339.4	0.92	7.0	8.0	
22.307	339.4	0.80	6.7	7.7	
1921.35	338.7	0.81	7.0	8.0	2n
1922.29	338.6	0.90	6.9	7.9	3n

6208 Lv 5 $12^{h}\,29^{m}$ −17° 39′

1921.297	12.4	. .	.	. .	
.324	16.6	1.12	7.0	10.0	(21)
1921.31	14.5	1.12	7.0	10.0	2-1n

6243 Σ 1670 $12^{h}\,37^{m}$ −0° 54′

1921.381	321.6	5.74	3.5	3.6	
.384	321.9	5.82	3.5	3.6	
.422	322.7	5.82	.		
.436	322.6	5.84	3.5	3.7	
1921.41	322.2	5.80	3.5	3.6	1n

6312 OΣ 256 $12^{h}\,51^{m}$ −0° 25′

1921.324	80.4	0.79	7.0	7.0	
.436	82.1	0.80	7.0	7.2	
1921.38	81.2	0.80	7.0	7.1	2n

6641 Σ 1785 $13^{h}\,15^{m}$ +27° 29′

1921.313	13.3	1.06	.	. . .	
.376	11.1	1.10	7.0	7.2	
.412	13.1	1.14	7.0	7.4	
.144	15.6	1.20	7.0	7.1	
147	13.3	1.18	7.0	7.2	
1921.40	13.9	1.11	7.0	7.2	5n

6955 Σ 1865 $14^{h}\,36^{m}$ +14° 09′

1921.349	138.2	0.88	4.4	4.0	
.376	137.2	1.05	4.2	4.0	
.411	138.3	0.85	4.0	4.1	
.436	136.6	0.96	4.0	4.1	
1921.39	137.6	0.91	4.2	4.1	4n

7034 Σ 1888 $14^{h}\,47^{m}$ +19° 31′

1921.436	59.7	2.55	5.0	7.0	
144	60.0	2.52	5.0	6.8	
.447	59.3	2.62	5.0	7.0	(22)
1921.41	59.7	2.56	5.0	6.9	3n

7214 Σ 1932 $15^{h}\,14^{m}$ +27° 14′

1920.178	14.7	0.61	6.0	6.2	
21.406	19.1	0.61	6.0	6.1	
21.436	17.9	0.61	6.0	6.1	
21.444	17.4	0.64			
1920.48	14.7	0.61	6.0	6.2	1n
21.43	18.1	0.62	6.0	6.1	3n

7487 Σ 1998 $15^{h}\,59^{m}$ −11° 07′

1921.436	183.5	1.16	5.0	5.2	
.603	183.4	1.09	5.0	5.1	
1921.52	183.5	1.13	5.0	5.2	2n

7563 Σ 2032 $16^{h}\,11^{m}$ +34° 07′

A and *B*

1921.633	219.6	5.03	5.0	6.2	
.636	219.8	5.15	5.0	6.4	
.639	220.6	5.14	5.0	6.2	
1921.64	220.0	5.11	5.0	6.3	3n

7649 Σ 2055 $16^{h}\,26^{m}$ +2° 12′

1921.436	85.4	0.92	4.0	4.8	
.592	85.1	0.70	4.0	4.7	
.603	82.9	0.85	4.0	5.7	
1921.54	84.5	0.82	1.0	5.1	3n

7717 Σ 2084 $16^{h}\,38^{m}$ +31° 47′

1921.633	81.2	1.66	3.0	6.0	
636	80.4	1.49	3.0	6.5	
.639	80.3	1.68	3.0	7.0	(23)
1921.64	80.6	1.61	3.0	6.5	3n

7834 Σ 2118 $16^{h}\,56^{m}$ +65° 11′

1921.729	78.7	0.58	.		
787	77.8	0.57			
1921.76	78.2	0.58	. .	. . .	2n

7878 Σ 2130 $17^{h}\,3^{m}$ +54° 36′

1921.636	122.8	2.12	5.0	5.1	
715	122.8	2.38	5.3	5.0	
.729	122.7	2.26	5.0	5.1	
1921.69	122.8	2.25	5.1	5.1	3n

7885 β 1118 $17^{h}\,5^{m}$ −15° 36′

1921.603	235.5	0.61			
.759	234.3	0.63	4.0	5.0	
1921.68	234.9	0.62	4.0	5.0	2n

8038 Σ 2173 $17^{h}\,25^{m}$ −0° 59′

1921.592	151.3	0.71	6.0	6.2	
.620	148.6	0.73	6.0	6.1	
.631	148.7	0.81	6.2	6.0	
1921.61	149.5	0.75	6.1	6.1	3n

8210 OΣ 338 $17^{h}\,48^{m}$ +15° 20′

1921.592	7.9	0.70	7.0	7.0	
.603	8.5	0.73	7.1	7.0	
1921.60	8.2	0.72	7.0	7.0	2n

8303 Σ 2262 $17^{h}\,58^{m}$ −8° 11′

1921.620	261.5	1.93	5.0	5.3	
.631	260.0	2.08	5.5	6.0	
.633	261.6	1.96	5.5	5.8	(24)
1921.63	261.0	1.99	5.3	5.7	3n

8340 Σ 2272 $18^{h}\,0^{m}$ +2° 32′

1921.620	132.0	5.62	4.5	5.5	
.631	131.9	5.60	4.5	6.0	
.633	131.9	5.51	4.5	6.2	
.639	130.9	5.54	4.5	6.5	
1921.63	131.7	5.57	4.5	6.0	4n

8380 Σ 2281 $18^{h}\,5^{m}$ +3° 58′

1921.592	65.5	0.67	6.0	7.5	
603	67.1	0.59	6.0	7.5	
.650	69.9	0.65	6.0	7.5	
1921.62	67.5	0.64	6.0	7.5	3n

8433 Σ 2291 $18^{h}\,9^{m}$ +0° 9′

1921.650	93.1	0.57			
.759	91.6	0.54		.	
1921.70	92.4	0.56		.	2n

8663 OΣ 358 $18^{h}\,31^{m}$ +16° 54′

1921.603	186.0	2.03	7.1	7.0	
.620	185.1	1.77	7.0	7.2	
631	185.0	2.08	7.0	7.1	
1921.62	185.4	1.96	7.0	7.1	3n

8751 Σ 2369 $18^{h}\,39^{m}$ +2° 31′

1921.592	81.5	0.93	8.0	8.5	
.603	89.4	0.99	8.0	8.4	
.620	83.2	1.06	8.0	8.2	
631	84.2	0.90	8.0	8.2	
1921.61	84.6	0.97	8.0	8.3	1n

8798 Σ 2398 18h 42m +59° 26'

A and B

1921.715	153.5	17.04	8.0	8.5	
.729	153.6	16.82	8.0	8.3	
.746	153.0	17.25			
.749	152.7	17.32			
1921.73	153.3	17.11	8.0	8.4	4n

A and C

1921.715	202.2	60.35		11.0	
.729	202.8	60.28		11.2	
1921.72	202.5	60.32		11.1	2n

8933 β 648 18h 53m +32° 46'

1921.620	34.8	1.02	6.0	8.5	
.633	35.4	0.89	6.0	8.0	
.650	40.4	1.00	6.0	8.5	
.729	38.0	1.11	5.0	8.0	
.759	37.9	1.21	6.0	8.5	(25)
1921.68	37.3	1.07	5.8	8.3	5n

8966 Σ 2438 18h 56m +58° 5'

1920.815	21.5	0.65			
20.853	22.8	0.66			
21.636	17.0	0.62			
21.715	14.7	0.65	7.0	7.7	
21.729	14.3	0.58	7.0	8.0	
1920.83	22.2	0.66			2n
1921.69	15.3	0.62	7.0	7.8	3n

9319 Σ 2525 19h 23m +27° 7'

1921.729	305.0	1.02	8.0	8.0	
.737	300.9	1.06	7.5	7.6	
.759	304.0	1.12	7.5	7.6	
.762	304.2	0.96			(26)
1921.75	303.7	1.04	7.7	7.8	4n

9456 Σ 2553 19h 32m +61° 19'

1921.808	101.9	0.86	8.0	9.2	
.830	103.4	0.83	8.0	9.5	
1921.82	102.6	0.84	8.0	9.4	2n

9602 Σ 2576 19h 42m +33° 22'

1921.636	275.8	1.66	8.1	8.0	
.715	274.4	1.75	8.0	8.1	
.729	275.7	1.75	8.0	8.1	
1921.69	275.3	1.72	8.0	8.1	3n

Jon 3023 19h 42m +40° 15'

1916.776	193.1	1.78	10.0	10.5	
.812	193.6	1.79	10.0	11.0	
1916.81	193.4	1.78	10.0	10.8	2n

9605 Σ 2579 19h 42m +44° 53'

1919.831	278.0	1.85	3.0	7.5	
21.636	276.4	2.07	3.0	7.0	
21.715	276.2	2.14	3.0	7.0	
21.729	277.6	2.12	3.0	7.5	(27)
1919.83	278.0	1.85	3.0	7.5	1n
1921.69	276.7	2.11	3.0	7.2	3n

9650 ΟΣ 387 19h 45m +35° 3'

1921.636	301.0	0.62	7.0	7.7	
.729	303.9	0.71	7.0	7.6	
.759	304.1	0.65	7.0	7.5	
.808	302.5	0.61	7.0	7.7	(28)
1921.73	302.9	0.65	7.0	7.6	4n

9979 ΟΣ 400 20h 7m +43° 38'

1921.636	335.4	0.71	7.0	7.5	
.729	334.4	0.66	7.0	7.3	
.759	334.3	0.66			
.830	338.0	0.57	7.0	7.2	
.836	338.4	0.67	7.0	7.3	(29)
1921.76	335.5	0.65	7.0	7.3	5n

10363 β 151 20h 33m +14° 15'

A and B

1919.629	342.7	0.48	5.0	5.8	
19.695	344.1	0.43	5.0	5.8	
19.763	346.5	0.47	5.0	5.8	
19.766	345.7	0.39	5.0	6.0	
19.831	340.6	0.46	5.0	6.0	
20.752	346.7	0.51	5.0	6.0	
20.768	349.9	0.59			
20.806	346.3	0.49	5.0	6.0	
20.826	347.8	0.53	5.0	5.7	
21.620	346.4	0.59	5.0	6.0	
21.636	347.5	0.59	5.0	6.0	
21.713	347.2	0.60			
21.737	347.2	0.62	5.0	6.3	
21.759	348.7	0.58	5.0	5.7	
21.836	347.8	0.60	5.0	6.0	(30)
21.915	350.0	0.62	5.0	5.9	
1919.74	343.9	0.45	5.0	5.9	5n
1920.79	347.7	0.53	5.0	5.9	4n
1921.75	347.8	0.60	5.0	6.0	7n

10363 β 151 20h 33m +14° 15'

AB and D

1919.695	328.5	38.52	5.0	9.5	
.717	328.8	38.91	5.0	10.0	
.766	328.6	38.30	5.0	10.3	
1919.73	328.6	38.58	5.0	10.0	3n

AB and C

1919.695	119.4	23.00		12.0	
.766	119.2	22.95		12.3	
1919.73	119.4	22.98		12.2	2n

10533 ΟΣ 413 20h 44m +36° 7'

1921.636	12.0	0.63	5.0	6.0	
.759	14.0	0.75	5.0	6.0	
.828	14.5	0.65	5.0	6.0	
1921.74	13.5	0.68	5.0	6.0	3n

10690 Σ 2746 20h 58m +38° 52'

1921.636	300.0	0.98	8.0	8.6	
.781	298.4	1.09	8.0	8.5	
.830	296.6	1.11	8.0	8.7	
1921.75	298.2	1.06	8.0	8.6	3n

10801 H I 47 21h 7m −15° 24'

1920.883	316.2	3.24			
.930	315.6	3.33	7.0	7.1	(31)
1920.91	315.9	3.29	7.0	7.1	2n

11031 Σ 2799 21h 24m +10° 39'

1921.737	289.3	1.52	6.5	6.7	
.770	289.8	1.47			
.833	288.7	1.17	6.6	6.5	
1921.78	289.3	1.49	6.5	6.6	3n

11214 Σ 2822 21h 40m +28° 17'

1921.781	138.4	1.38	5.0	6.3	
.803	139.5	1.36	5.0	7.0	
.806	140.5	1.35	5.0	7.0	
.828	139.8	1.46	5.0	7.5	
.830	138.9	1.47	5.0	6.7	
1921.81	139.4	1.40	5.0	6.9	5n

11743 Σ 2909 22h 24m −0° 32'

1921.912	303.8	2.69	4.0	4.2	
.937	304.4	3.09	4.0	4.2	
.991	303.4	2.72	4.0	4.4	(32)
1921.95	303.8	2.83	4.0	4.3	3n

12094 ΟΣ 483 22h 54m +11° 12'

1921.803	242.5	0.90	7.0	8.5	
.830	238.0	0.98	6.0	7.5	
.836	240.4	0.84	6.0	7.5	
1921.82	240.3	0.91	6.3	7.8	3n

12213 Σ 2988 23h 7m −12° 29'

1921.915	279.2	3.51	7.0	7.1	
.937	276.2	3.55			
.991	279.4	3.50	7.5	7.5	(33)
1921.95	278.3	3.52	7.2	7.3	3n

12675 Σ 3050 23h 54m +33° 10'

1921.828	227.2	1.93	6.0	6.3	
.913	228.1	1.90	6.0	6.8	
.915	227.7	2.00	6.2	6.0	
1921.89	227.7	1.91	6.1	6.4	3n

12755 Σ 3062 0h 1m +57° 53'

1920.930	17.6	1.39	7.0	7.7	
21.020	20.0	1.41	7.0	8.0	
21.075	19.5	1.18	7.0	7.7	
22.019	22.7	1.50	6.5	7.0	
22.027	22.3	1.50	6.0	6.7	[illegible]
1921.01	19.0	1.41	7.0	7.8	3n
1922.02	22.5	1.50	6.2	6.8	2n

NOTES

(1) Apparently fixed.

(2) Same increase in distance with a little increase in angle. Probably moving in a very elongated ellipse.

(3) Angle decreasing 0°.5 a year.

(4) In close agreement with *Lohse's Elements Potsdam* V. XX.

(5) *Jackson's Ephemeris M. N.*, V. LXXX agrees well with late measures. Angles seem about 2° too small and the distances about 0″.1 too great.

(6) Yearly motion −0°.06 +0″.006.

(7) Hussey's Ephemeris *Lick*, V. V represents late measures well; the angles being about 2° too small and the distances 0″.05 too large.

(8) Maximum distance of 3″.1 reached about 1920.

(9) Maximum distance of 1″.4 reached about 1920.

(10) Motion decidedly elliptical.

(11) Yearly motion −0°.08 −0″.003.

(12) In close agreement with orbit by Van den Bos *M. N.*, V. LXXXI.

(13) Angle decreasing 0°.1 a year.

(14) Angle increased 7° since 1822; distant constant at 2″.6.

(15) Yearly motion −0°.02 −0″.01.

(16) In close agreement with Doberck's Ephemeris, *A. N.* 4144.

(17) Comparison with Schoenberg's Ephemeris, *A. N.*, 4260 gives O — C +3°.5 −0″.01.

(18) Almost stationary during last 5 years.

(19) Yearly motion rectilinear +0″.01.

(20) Apparent orbit in *M. R. A. S.* V. LVI appears too elliptical.

(21) Yearly motion −0°.5 −0″.01.

(22) In close agreement with Doberck's Elements *A. N.* 5118.

(23) Agrees well with Comstock's Ephemeris, *A. J.* 712.

(24) Maximum distance of 2″.0 reached about 1910.

(25) Aitken's Ephemeris, *Lick*, V. XII O — C +35°.9 +0″.53.

(26) Doberck's Ephemeris, *A. N.* 4515 +4°.0 +0″.24. Jackson's Ephemeris, *M. N.*, V. LXXX +2°.4 +0″.13.

(27) Jackson's Ephemeris *M. N.*, V. LXXX +0°.9 +0″.37.

(28) Jackson's Ephemeris, *M. N.* V. LXXX −1°.5 +0″.15.

(29) Maximum distance 0″.65 and period about 76 years.

(30) Lohse's Ephemeris, *Potsdam*, V. XX.

O — C	1919.74	+3°.9	−0″.08
	1920.79	+3 .2	−0 .07
	1921.75	+0 .1	−0 .05

(31) Yearly motion −0°.1 +0″.01.

(32) Binary.

(33) Angle decreased 4° in 100 years.

(34) Lohse's Ephemeris, *Potsdam*, V. XX.

O — C	1921.01	−2°.8	−0″.05
	1922.02	−1 .3	+0 .03

OBSERVATIONS OF *MIRA CETI*.

By ELIAS BRESON.

I have observed the variable star *Mira Ceti* ($2^h\ 14^m\ 3.$ $-3°\ 26'$), using the following comparison stars.

α *Ceti*	2.89	*P. G. K.*	63 *Ceti*	5.88	*P. D.* XLV Bulletin de la Soc. Vaudoise v. 46, p. 169
α *Arietis*	2.19	*P. G. K.*	66 *Ceti*	5.63	(same)
α *Piscium*	4.12	*P. G. K.*	η *Ceti*	3.61	(same)
γ *Ceti*	3.80	*P. G. K.*	τ *Ceti*	3.71	(same)
μ *Ceti*	4.41	*P. G. K.*	75 *Ceti*	5.60	*B. D.*
ξ¹ *Ceti*	4.70	*P. G. K.*	71 *Ceti*	6.30	Schurig
ξ² *Ceti*	4.48	*P. G. K.*	*B. D.* −3° 372	7.22	*Harvard Ann.* 91
ξ *Piscium*	4.91	*P. G. K.*	−4° 379	8.05	*Harvard Ann.* 91
δ *Ceti* (corrected)	4.01	*P. G. K.*			

The last two stars are designated *a* and *b* respectively in the observations.

My instrument was a Zeiss Binocular, 6x; later, from Nov. 14, 1919, a Busch Binocular (Terlux), 10x. The Argelander step method was used; each step = 0.1 mag. All estimates are given the same weight. No correction has been applied for extinction = about −0.23 Potsdam scale. I used a Stromgren-Olsen chronometer, set by the official time-ball at the port.

The following color scale has been used:

0.0	Pure white	8.0	Reddish
6.0	Orange	8.5	Rosy
6.5	Faint golden yellow	9.0	copper red
7.0	Golden yellow	9.5	Red (pure)
7.5	Faint reddish	10.0	Deep (blood) red

The color 10.0, deep red, has been noted 22 times out of 67 color estimates.

Date		G. M. T.	Comp.	*Mira*	Weather	Color
		h m				
1918	Sept. 19	9 55	α *C* 5 *M* = α *P*	3.75	Smoky	10.0
	Oct. 1	9 17	α *C* 5 *M* 2 α *P*	3.65	Clouds	8.0
	2	9 25	α *P* 0.5 *M*	4.08	Clear	10.0
			γ *C* 2 *M*			
	6	8 30	*M* 2 α *C*	2.69	Wind	10.0
	21	9 30	γ *C* = *M*	3.80	Hazy, clds.	9.5
	25	9 30	γ *C* 1 *M* 1 α *P*	3.96	Clear	10.0
	27	8 0	γ *C* 2 *M* 1 α *P*	4.01	Clouds	9.0
	28	8 20	γ *C* 0.5 *M* 1 α *P*	3.93	Haze	10.0
	30	8 25	α *P* = *M*	4.06	Wind, haze	10.0
			γ *C* 2 *M*			
	Nov. 9	7 53	α *P* 0.5 *M*	4.13	Clear	9.5
			γ *C* 3 *M*			
	11	7 52	γ *C* 3 *M* = α *P*	4.11	Haze, *moon*	9.5
	12	9 37	α *P* 0.5 *M*	4.17	Haze	7.5
	21	7 45	δ *C* 1 *M*	4.11	Clear	8.0
	22	7 3	δ *C* 1 *M*	4.14	Wind,	9.5
			α *P* 0.5 *M*		Clear	
	23	7 43	δ *C* 0.5 *M*	4.14	Haze	8.0
			α *P* 1 *M*			
	Dec. 22	6 0	ξ *P* 3 *M*	5.21	Haze	6.0
1919	Jan. 7	7 15	ξ *P* 3 *M*	5.21	Clear	9.0
	Aug. 23	13 52	α *C* 3 *M* 4 γ *C*	3.29	Clear	9.0
	31	13 25	α *C* 3 *M* 2 γ *C*	3.39	Clear	9.5
	Sept. 2	13 40	α *C* 3 *M* 3 γ *C*	3.34	Clear	9.5
	3	13 20	α *C* 3 *M* 2 γ *C*	3.39	Clear	9.5
	5	14 15	α *C* 4 *M* 2 γ *C*	3.44	Clear	9.5
	6	13 2	α *C* 3 *M* 3 γ *C*	3.34	Haze	9.5
	11	14 24	*M* 2 γ *C*	3.60	*Moon*, haze	9.5
	12	15 15	α *C* 3 *M* 2 γ *C*	3.39	*Moon*, haze	8.0
	15	15 35	*M* 2 γ *C*	3.60	*Moon*, haze	9.5
	16	14 10	*M* 1 γ *C*	3.70	Clouds	9.5
	17	14 55	*M* 1.5 γ *C*	3.65	Clear	9.5
	22	12 37	γ *C* 0.5 *M*	3.85	Clear	9.5
	27	12 0	γ *C* 2 *M*	4.00	Clear	10.0
	30	14 33	γ *C* 2 *M*	4.00	Clear	9.5
	Oct. 3	11 12	γ *C* 0.5 *M* 1 δ *C*	3.98	Clear	9.5
	4	11 12	γ *C* 2 *M* = δ *C*	4.00	Clear	9.5
	15	10 15	ξ *P* 1 *M*	5.01	Haze	9.5
	16	9 30	ξ *P* 1 *M*	5.01	Clear	10.0
	17	9 34	ξ *P* = *M*	4.94	Clear	10.0
	Oct. 22	9 4	ξ *P* 1 *M*	5.01	Clear	9.5
	24	9 20	ξ *P* 3 *M*	5.21	Clear	9.5
	26	10 35	*M* 3 66 *C*	5.33	Haze	8.0
	30	9 7	*M* 1.5 66 *C*	5.48	Haze	9.5
	Nov. 1	8 35	*M* 1.5 66 *C*	5.48	Clear	9.5
	11	7 38	63 *C* = *M*	5.88	Clear	9.5
	16	7 0	63 *C* 2 *M*	6.08	Clear	8.0
	21	6 45	*M* 2 71 *C*	6.10		7.5

Date		G. M. T.	Comp.	*Mira*	Weather	Color
		h m				
1919	Dec. 10	8 0	$M = b$	8.0	Clear	..
1920	Sept. 11	11 5	ξ P 3 M	5.21	Clear	9.5
	12	11 45	ξ P 3 M 4 66 C	5.22	Clear	9.5
	14	10 50	M 4 66 C	5.23	Haze	9.5
	19	10 38	M 3 75 C	5.30	Clear	9.5
	20	10 25	M 0.5 75 C	5.55	Clear	9.5
	21	10 55	75 C 2 M	5.80	Haze	9.5
	23	10 4	75 C 2 M	5.80	Haze	9.5
	Oct. 3	9 24	M 1 63 C	5.78	Wind	10.0
	4	10 0	63 C 2 M	6.08	Wind	10.0
	5	10 31	63 C 1 M	5.98	Haze	8.0
	9	9 52	63 C 2 M	6.08	Haze	10.0
	10	9 52	$M = 71$ C	6.30	Haze	10.0
	13	9 25	71 C 1 M	6.40	Haze	8.0
	16	11 38	71 C 2 M	6.50	Clear	10.0
	17	10 28	M 2 a	7.0	Clear	10.0
	18	8 52	M 1 a	7.1	Clear	10.0
	19	9 20	$M = a$	7.2	Haze	10.0
	20	10 2	M 1 a	7.1	Clear	10.0
	21	10 20	M 2 a	7.0	Haze	10.0
	31	9 30	a 2 M	7.4	Wind	10.0
	Nov. 1	8 7	$b = M$	8.0	Clear	7.5(?)
	2	8 50	b 3 M	8.3	Haze	10.0
	3	9 48	b 1 M	8.1	Clear	10.0
	10	10 10	b 4 M	8.4	Haze	...
	11	8 25	b 3 M	8.3	Haze	...
	17	7 2	b 4 M	8.4	Haze	...
	24	Even'g	Not seen	<9.0	....	...
	Dec. 20	8 55	Not seen	<9.0	....	...
	29	Even'g	Not seen	<9.0	....	..

I tried to identify *Mira* in the autumn of 1921, but without result.

Helsingor, Denmark, 1922, Aug. 26.

OBSERVATIONS OF THE ASTEROID *EROS* IN 1921,

WITH THE 40-INCH AND 12-INCH REFRACTORS OF THE YERKES OBSERVATORY,

By G. VAN BIESBROECK.

1921	G. M. T.	$\Delta\alpha$	$\Delta\delta$	α app.	δ app.	log $p_\alpha\Delta$	log $p_\delta\Delta$	Instr	★
	h m s	m s	′ ″	h m s	° ′ ″				
Aug. 14	18 38 22	−0 5.28	+2 41.4	23 32 13.83	+11 27 44.2	9.155n	0.661	40	1
18	20 42 46	+ 7.88	+5 0.0	27 53.28	12 7 4.0	9.120	.652	40	2
Sept. 1	20 32 29	+ 12.43	−2 59.5	7 12.94	13 41 14.0	9.393	.651	40	3
5	16 36 55	− 16.94	−9 3.1	23 0 20.06	53 27.0	9.176n	.632	12	4
6	20 25 19	− 33.22	−2 40.0	22 58 10.96	55 55.6	9.454	.657	40	5
7	15 2 42	− 16.69	−2 2.2	56 45.27	57 18.5	9.460n	.658	10	6
8	20 27 36	− 14.06	+3 58.1	54 26.83	58 53.9	9.479	.662	40	7
11	16 59 40	+ 18.17	−0 49.4	49 3.57	59 54.1	8.610n	.621	40	8
14	16 17 35	−0 7.00	−4 5.7	22 43 27.28	13 57 17.4	8.946n	0.625	40	9

1921	G. M. T.	$\Delta\alpha$	$\Delta\delta$	α app.	δ app.	$\log p_\alpha\Delta$	$\log p_\delta\Delta$	Instr.	★
	h m s	m s	′ ″	h m s	° ′ ″				
Sept. 17	20 22 14	+0 1.00	+0 4.0	22 37 33.53	13 50 36.0	9.593	0.700	10	10
18	16 37 12	+ 15.30	+2 16.6	36 1.87	18 42.8	7.748n	.624	10	11
24	16 21 6	+ 0.53	+1 18.1	30 43.14	37 25.8	7.564n	.626	40	12
25	16 12 59	− 10.79	+8 45.9	21 1.59	13 19 1.5	8.381	.630	40	13
30	13 26 6	+ 10.66	+1 58.8	16 51.42	12 51 8.4	9.374n	.658	12	14
Oct. 2	14 30 55	− 11.24	+5 8.4	14 14.02	12 38 9.2	9.003n	.643	10	15
3	14 33 7	+ 6.04	−0 24.1	12 57.57	12 31 46.8	8.938n	.643	12	16
12	15 52 39	− 2.55	+1 6.0	1 32.07	11 30 25.2	9.172	.661	40	17
13	13 26 6	− 1.12	+1 9.9	3 58.60	11 24 29.8	9.084n	.660	40	18
23	13 39 13	+ 13.38	−0 25.4	0 57.66	10 23 3.5	8.175n	.668	40	19
Nov. 6	12 48 53	+ 9.04	+0 6.9	6 11.79	9 25 50.3	8.226n	.679	40	20
9	15 31 16	− 0.96	−5 14.8	8 41.49	9 18 52.6	9.459	.703	40	21
20	13 35 19	−0 0.23	−4 58.4	22 20 15.27	+ 9 12 17.5	9.167	0.687	40	22

Comparison Stars

★	$\alpha_{(1921.0)}$	$\delta_{(1921.0)}$	Red. ad loc. app. $\Delta\alpha$	Red. ad loc. app. $\Delta\delta$	Authority
	h m s	° ′ ″	s	″	
1	23 32 15.56	+11 24 12.1	+3.55	+20.4	*B. D.* 11° 5029 ref. to *A. G. Lpz. I* 9386
2	23 27 11.77	12 4 12.8	3.63	21.2	Anon. ref. to *A. G. Lpz. I* 9354
3	23 6 56.68	13 14 35.8	3.83	24.2	Bord. ph. +14°, 23h 4m, No. 85
4	23 0 33.45	14 2 5.0	3.85	25.1	*A. G. Lpz.* 9201
5	22 58 40.32	13 58 10.3	3.86	25.3	Bord. ph. +14°, 22h 56m, No. 138
6	56 58.10	13 58 55.2	3.86	25.5	Bord. ph. +14°, 22h 56m, No. 121
7	51 37.03	13 54 30.4	3.86	25.7	Bord. ph. +14°, 22h 56m, No. 97
8	48 44.54	14 0 47.4	3.86	26.4	Bord. ph. +14°, 22h 48m, No. 209
9	43 30.43	14 0 56.2	3.85	26.9	Bord. ph. +14°, 22h 40m, No. 192
10	37 28.70	13 50 1.6	3.83	27.4	Bord. ph. +14°, 22h 40m, No. 124
11	35 12.75	13 44 58.6	3.82	27.6	Bord. ph. +14°, 22h 32m, No. 203
12	30 39.12	13 35 19.6	3.79	28.1	Bord. ph. +14°, 22h 32m, No. 131
13	24 44.63	13 9 50.0	3.75	28.6	Kü 9955
14	16 37.08	12 45 10.4	3.68	29.2	Kü 9896
15	14 54.57	12 32 31.5	3.66	29.3	Kü 9882
16	12 47.94	12 34 44.5	3.65	29.4	*A. G. Lpz. I* 8895
17	1 31.10	11 28 19.4	3.52	29.8	*A. G. Lpz. I* 8833
18	3 56.24	11 22 50.4	3.48	29.8	*B. D.* 11° 4732 ref. to *A. G. Lpz. I* 8826
19	0 40.94	10 22 58.9	3.34	29.7	*A. G. Lpz. I* 8802
20	5 59.62	9 25 44.4	3.16	29.3	Tou. ph. +9°, 22h 4m, No. 129
21	8 39.31	9 23 38.4	3.14	29.3	Tou. ph. +9°, 22h 4m, No. 170
22	22 20 12.11	+ 9 16 46.9	3.06	28.7	Tou. ph. +9°, 22h 20m, No. 27

Benjamin Boss.
July, 1922.

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MERIDIAN CIRCLE LATITUDES,

By R. H. TUCKER.

The astronomical latitude is defined as that given by an adopted system of stars. We have generally reduced our values with the declinations of the new system of AUWERS, but there have been departures from this practice, each one covering at least a year of observation.

The following values from circumpolar stars at both culminations were summed up two years ago, upon request for the data. The stars are not the same in all the years, as some years include a larger proportion of our list of 48 stars, and only the values from double culminations have been included. The observed latitudes have been corrected for the latitude variation, from the results of the International zenith telescope stations, at the epochs of our observations. Corrections to the Poulkova refractions have been applied, as required at this station.

EPOCH	φ_0	WT.
1893.7 to 1896.5	37° 20′ 25″.80	3
96.6 to 97.8	69	1
97.8 to 98.4	70	1
98.7 to 1900.5	73	3
1901.4 to 4.3	80	4
5.5 to 6.5	83	1
14.1 to 15.0	68	2
17.1 to 18.2	66	2
Weighted Mean	25.75	

The weights were assigned according to the number of weights in each result, nearly nine hundred in all. The average residual for weight one is $\pm 0''.05$. The computed least squares rate in φ_0 would be $-0''.003$ per year, but this computed rate has no real significance in comparison with the accidental errors of the individual results. The mean epoch is 1904, and there are thirteen full years included.

Since the errors of the adopted declinations have been eliminated, and all the results are affected by the same classes of systematic errors, the series should be suitable for a study of changes of latitude. If there is a sudden change it should appear in the annual values, as well as in those close to the epoch of change. There appears to be a fairly regular increase from 1897 to 1906, followed by a fall. A similar fall would precede 1897. If we could assume that the systematic errors were invariable throughout this period of a quarter of a century, there might be some slight significance in the differences of φ_0. From the average residual, the legitimate difference to be expected between two values is $0''.07$, and the distribution of accidental errors allows for at least one difference of twice the average size — which is what appears, following 1906. The long interval, in which no yearly results were available for tabulation, may partially account for this largest difference between consecutive values. The average is $\pm 0''.06$.

The latitude from these observations of circumpolar stars is subject to various systematic errors. Bisection error will affect the results at both culminations by the same amount, on the presumption that it is constant for all zenith distances. My error at the zenith, derived from several hundred measures, is $0''.05$, and the correction is to be applied with the contrary sign to that for the atmospheric refraction.

Flexure is very small for this instrument. From many sets of measures at various epochs the semi horizontal flexure does not exceed $0''.1 \sin$ Z.D. and the correction is to be applied with the same sign as that for refraction. Whether we apply both corrections or omit both, the latitude from circumpolars will be about the same.

The effect of graduation errors enters each result, and there are separate errors for upper and lower culminations. There appears to be no periodic term in our errors of graduation, measured thus far for each 10′ of the fixed circle. They are nearly fortuitous in character, and average $\pm 0''.15$ for the mean of four divisions, the graduation error of the nadir reading

affects the latitude results from all stars by the same amount in one position of the instrument, using the fixed circle. The effect is eliminated from the mean results in both positions of the instrument, and our observations of circumpolar stars have been well distributed in both. Some use has also been made of the movable circle, shifting it for each night, thus introducing an accidental error in place of the systematic error for any individual star.

There is also a systematic error in setting upon the nadir, one of the forms of personal equation which we are accustomed to assume as invariable — for which assumption there is unfortunately no direct test.

The only control of changes in flexure and in bisection error is to make repeated measures, adopting a mean value unless the evident change is larger than might be due to the errors of measurement. Actual changes may account for some of the differences between our computed results.

The Poulkova refractions appeared to satisfy the results from circumpolar stars and from stars at the equator, on the old system of AUWERS, in my earliest work with this instrument. Subsequent observations at greater zenith distances, including lower culminations of stars south of 70°, established a correction of $-0''.2$ tan Z.D. during the night hours. The declination system at the equator accordingly requires a correction, which is confirmed by other sources of information. Recent work has established a diurnal term in the refraction correction at this station, amounting to $0''.5$ tan Z.D. between day and night. This is of importance in deriving latitudes from consecutive transits of the same circumpolar at upper and lower culminations.

Our fundamental work gives us a diurnal term in the observed latitudes, of the form $+0''.14$ cos T, where T is reckoned from noon. This variation depends in large part upon observations close to the zenith, and should not be due to refraction errors. It may possibly indicate a small correction to the adopted constant of nutation, and may be another expression of the periodic term that is evident in clock corrections near sunset and sunrise, and in clock rates during the night. Thus, in addition to the accidental errors, the effect of which may be diminished by numerous observations, these yearly latitude results are affected by systematic errors of bisection, flexure, graduation, Nadir, and refraction. Some of these systematic errors may not be constant. Nearly all of them are virtually eliminated in our observations of declinations.

We were requested nearly two years ago to furnish our latitude results for each quarter of a year. The errors of the declinations adopted for the circumpolar stars are not eliminated in quarterly values of φ_0. The results from observations of fundamental stars, which are more than twice as numerous, were accordingly combined with those of the circumpolars. The following tabulated φ_0 is in each case the half sum of the latitudes from circumpolar stars and from fundamental stars, generally south of the zenith.

On the general principle that it is better to eliminate errors than to measure them and apply the corresponding corrections, this combination presents some definite advantages. Bisection error and flexure should closely balance in effect for stars at the equator and the circumpolars at upper culmination, of average declination 75°. Errors of the adopted refraction should nearly balance. All three should similarly nearly balance for stars at $-30°$, and the circumpolars at lower culmination. No system of weighting will lead to any practical improvement of the half sum, since the systematic errors to be eliminated are likely to be of more importance than the accidental errors of observation. Changes in some of the systematic errors do not affect the adopted half sum of the latitudes, from stars north and south of the zenith, at nearly the same angular distance from it.

In one year there are only the results from observations of a list of close circumpolar stars. One half the correction to AUWERS' system at the equator has been applied to the quarterly φ_0 for that year, with the contrary sign. This is the only correction applied that depends upon our own results of observation.* In other the cases one half the systematic differences of the catalogue declinations have been applied.

These corrections are not rigorously applicable to quarterly φ_0, since there is a periodic term in each $\Delta\delta$. Even in the yearly φ_0 the corrections are not rigorously exact, since $\Delta\delta$ has been computed from all the stars common to two catalogues. But they are close approximations to the proper corrections, and the best that can be derived without going into excessive detail.

In the case of NEWCOMB, which contains fifty per cent more stars than AUWERS, many stars were observed for which there was no $\Delta\delta$ available. The correction is correspondingly uncertain.

The observations of the first three years were reduced with declinations of the old system of AUWERS, between $-10°$ and $+15°$. The catalogue $\Delta\delta$ is $0''.01$ for this zone, and no correction has been applied. The correction to N.B.S. is one half $\Delta\delta$ between the equator and $+70°$. For AUWERS' southern catalogue of 303

*The correction is derived from all our work, and is applied for this one year only.

fundamental stars the correction to reduce to the old B.J. system, given in the *Jahrbuch* for 1900, was $-0''.50 + 0''.02\ \delta°$. To reduce to the new B.J. system the correction is $-0''.15 + 0''.015\ \delta°$, and one half of this has been applied, for the mean declination $-13°$.

For NEWCOMB one half the $\Delta\delta$ between $-30°$ and $+30°$ has been applied. For Boss P.G.C. one half the $\Delta\delta$ between $-30°$ and $+70°$.

Observations in 1907, 1916 and three isolated values later than 1918 have been added to the data originally compiled. The occurrence of three earthquakes of sensible character, (perhaps a mild designation), has been noted. Two or three months of observation have been included in each quarterly value, since gaps in observation render a uniform combination of three successive calendar months impossible, in many cases. The last three have been corrected for latitude variation by the computed expression for $\varphi - \varphi_0$. Each quarterly value is subject to a correction of the half sum of the errors of declination of the circumpolar stars observed, and those of the accompanying fundamental stars. An average of about twenty nights has been included in each quarterly φ_0. The mean φ_0 is 37° 20′ 25″.595 (±0″.013), with the use of AUWERS declinations for the fundamental stars. The application of the systematic corrections for other authorities has reduced the mean value by less than 0″.03. The residuals are distributed closely according to the law of distribution of accidental errors. Out of 67 residuals there are 30 that exceed the probable error,

QUARTERLY φ_0 LICK OBSERVATORY MERIDIAN CIRCLE

AUWERS	B. J.	Corr.	B. J.	v	NEWCOMB		Corr.	B. J.	v	AUWERS	B. J.	v
	″		″	″		″	″	″	″		″	″
1893.82	25.48		25.48	−0.11	1900.89	25.64	−0.07	25.57	−0.02	1907.73	25.54	−0.05
94.12	69		69	+ 10	1.46	94	− 07	87	+ 28	8.33	30	− 29
94.33	47		47	− 12	1.57	26.03	− 07	96	+ 37	Earthquake		
94.51	44		44	− 15	1.92	25.71	− 07	64	+ 05			
94.83	43		43	− 16	2.13	90	− 07	83	+ 24	12.18	79	+ 20
95.11	61		61	+ 02	2.37	76	− 07	69	+ 10	12.51	60	+ 01
95.33	57		57	− 02	2.62	87	− 07	80	+ 21	12.75	38	− 21
95.63	52		52	− 07	2.88	68	− 07	61	+ 02	12.92	78	+ 19
Earthquake					3.12	65	− 07	58	− 01	13.16	68	+ 09
95.83	56		56	− 03	3.37	90	− 07	83	+ 24	13.53	32	− 27
96.11	82		82	+ 23	Earthquake					14.14	68	+ 09
96.40	72		72	+ 13	3.87	37	− 07	30	− 29	14.37	67	+ 08
Boss N. B. S.					4.11	48	− 07	41	− 18	14.63	52	− 07
		″			4.30	76	− 07	69	+ 10	14.90	59	00
96.67	43	+0.12	55	− 04						16.25	63	+ 04
96.91	52	+ 12	64	+ 05	AUWERS B. J.					16.54	85	+ 26
97.13	41	+ 12	53	− 06						16.80	40	− 19
97.31	47	+ 12	59	00	5.59	26		26	− 33	17.18	34	− 25
Close Circumpolars					5.77	12		42	− 17	17.39	58	− 01
		″			6.11	58		58	− 01	17.62	54	− 05
97.72	62	−0.15	47	− 12	Earthquake					17.88	51	− 08
97.92	67	− 15	52	− 07	6.45	63		63	+ 04	18.11	55	− 04
98.15	94	− 15	79	+ 20						20.86	73	+ 14
98.36	65	− 15	50	− 09	Boss P. G. C.					21.41	89	+ 30
										22.43	70	+ 11
AUWERS 303					6.84	54	+0.05	59	00			
		″			7.33	50	+ 05	55	− 04	Mean	25.59	
98.83	77	−0.17	60	+ 01	7.82	65	+ 05	70	+ 11			
99.12	86	− 17	69	+ 10						Average		±0.12
99.32	82	− 17	65	+ 06								
99.63	58	− 17	41	− 18								
1900.38	73	− 17	56	− 03								

±0″.10. There are 14 that exceed twice the probable error, and the theoretical distribution allows 11. There are 2 that exceed three times the probable error, and theory allows that number. There are 31 plus, 33 minus residuals and 3 of zero.

The run of the differences between consecutive values, from which sudden changes of position might be predicated, follows the law of distribution of accidental errors equally well. There are 33 plus differences and 33 minus. The average is ±0″.165. Out of 66 differences there are 35 that exceed the probable error, ±0″.14. There are 10 that exceed twice the probable error, and theory allows 11. There are four that exceed three times the probable error, while theory allows for two. None are as large as four times the probable error, for which theory allows us one in about one hundred and fifty residuals. The two largest are for the intervals in which the 1903 and 1911 earthquakes occurred. Their size is more likely to be due to the chance juxtaposition of two rather large residuals of φ_0 of contrary signs in each case, than to an actual shift of position.

Moreover, there are distinct deviations of the seasonal latitudes, which evidently correspond to the periodic term in $\Delta\delta$, summed up in combinations of six hours each.* The above table gives the following mean values for this periodic term in observed latitude.

SUMMATION QUARTERLY φ_0

EPOCH	NO.	φ_0	v
1906.13	15	25″.63	+0″.04
.36	19	.63	+ .04
.62	15	.54	− .05
.86	18	.56	− .03

The average difference between the second and fourth quarters is −0″.07, due to systematic errors of declinations, and this should be taken into account in the 1903 results. Considerable discussion has arisen over that particular difference, and it seems proper to give the values for that year in detail.

All of the nights of June gave values of φ_0 above 26″, and the relatively large difference between the second and fourth seasons is more probably due to the exceptionally high φ_0 in June, than to the earthquake in August.

The yearly values of φ_0 have the declination errors of the circumpolar stars practically eliminated. There remains, as a systematic correction, one half the correction to the declination system of AUWERS, for stars which extend from −31° to +70° in various periods of

MONTH	NIGHTS	EPOCH	φ_0	v
Jan.	8	1903.03	25″.76	+0.″12
Feb.	8	14	61	− 03
Mar.	2	19	57	− 07
Apr.	6	32	68	+ 04
May	11	37	85	+ 21
June	4	43	26.16	+ 52
EARTHQUAKE				
Oct.	2	76	25.61	− 03
Nov.	2	88	26	− 38
Dec.	8	97	25	− 39
Mean by months		(9)	25.64	
Mean by nights		(51)	(25.66)	

Average residual ±0.20

the observations. The following combinations of quarterly values have been made without including two at the same season of the year, except in those for 1899, 1907 and 1921. There are many isolated groups of observations that are not included in the compilation, not having enough individual weight.

The four values, 1901 to 1904, in which the declinations of NEWCOMB were employed, have a mean resi-

YEARLY φ_0

EPOCH	NO.	φ_0	v	$\Delta\varphi_0$
1894.2	4	25″.52	−0″.07	......
95.2	4	53	− 06	+0″.01
96.1	3	70	+ 11	+ 17
97.0	4	58	− 01	− 12
98.0	4	57	− 02	− 01
99.5	5	58	− 01	+ 01
1901.3	3	80	+ 21	+ 22
2.3	1	74	+ 15	− 06
3.1	3	67	+ 08	− 07
4.1	3	47	− 12	− 20
6.0	4	47	− 12	00
7.3	3	61	+ 02	+ 14
8.0	2	42	− 17	− 19
12.6	4	64	+ 05	+ 22
13.3	2	50	− 09	− 14
14.5	4	61	+ 02	+ 11
16.7	4	56	− 03	− 05
17.7	4	55	− 04	− 01
21.6	3	77	+ 18	+ 22
Sum 67				
Mean (19)		25″.59		
Average			±0″.08	±0″.10

*Astronomical Journal No. 809.

dual 0″.1 higher than the remainder of the list. Any apparent upward trend in our latitude is more likely to be due to the undetermined corrections to that system, than to actual movement of the observing station.

The φ_0 for 1903 precedes the earthquake of that year, and the φ_0 for 1904 follows it. The difference between the two, $-0''.20$, is exceeded in size by three other differences between consecutive yearly values. One of these comes in the interval corresponding to the 1911 earthquake, and is of the opposite sign.

For the entire series the least squares rate of φ_0 is less than 0″.001 per year. This indicates that the systematic error of the proper motions of AUWERS must be negligible. The same would be true for those of NEWCOMB. The mean difference of BOSS from the other two authorities is 0″.002. These figures do not give support to the recent hypothesis of KAPTEYN that the mean error is above 0″.01.

Dividing our series into two parts, the mean φ_0 from 1893 to 1903 inclusive is 25″.63, and the computed rate is +0″.02 per year. From 1904 to 1922 the mean is 25″.56, and the rate is +0″.01. Apparently there was a decrease of 0″.07, following the 1903 earthquake. This decrease and the resulting rates are most probably due largely to the uncorrected declinations of NEWCOMB. If the four years of use of that system are not included in the computation, the mean is 25″.57, and the rate is +0″.002. Computed values are so largely influenced by errors of declination, proper motion and observation that caution should be exercised in drawing conclusions as to real changes in the position of the observing station.

Lick Observatory,
July 15, 1922.

ON THE DAILY VARIATION IN CLOCK CORRECTIONS,

BY H. R. MORGAN.

[Communicated by CAPTAIN W. D. MACDOUGALL, Superintendent, U. S. Naval Observatory.]

In the *Astronomical Journal*, No. 795, it was shown that the daily variation in the clock corrections as determined from observations taken on the 9-inch transit circle of the U. S. Naval Observatory, from 1903 to 1911, was a negligible quantity; and in the present paper the observations from 1913.5 to 1920.9, which were taken under a slightly different plan of work, are similarly discussed.

During this period observations of clock stars were commenced soon after sunset in the evenings and concluded shortly before sunrise in the mornings; no observations being taken with the *Sun* less than 6° below the horizon. The observers on the two halves of a night alternated, such that each preceded and followed every other one within a fortnight; with the result that any uncertainty in the relative equations, as determined and applied, would be eliminated from groups of day to day clock rates, and from groups of differences morning minus evening clock corrections. By means of a variable screen system the magnitude of observation of all stars was about 9.0. The screens also cut out twilight so that artificial field illumination was always used.

The instantaneous values of the collimation, level, and azimuth of the instrument were determined every three or four hours from sunset to sunrise. The azimuth was given by readings on the north and south meridian marks, and mean group positions of the marks were determined from observations of circumpolar stars at each end of the night; and in each group each observer took an equal number of observations above and below pole of a given star. In the preliminary reductions the azimuth of the marks was taken as constant throughout the night, and for a number of weeks at a time. From the present examination of some 1,700 observations of azimuth stars it was found that the mean azimuth of the marks was 0ˢ.012 greater in the morning than in the evening. The difference, morning minus evening, shows a small variation during the year, as shown in Table I; and is similar year to year, as shown in Table II. The positions of the azimuth stars used were from fundamental observations in 1908–1911.

The positions of the 186 clock stars used in determining the clock corrections were derived from a discussion of 1,348 observations on 303 complete nights during the period 1913.5–1918.5; the period of observing varying from 8 hours on a summer night to 14 hours on a winter night. This system agrees closely with that derived from 7,000 observations during the period 1903–1911.

The rates of the clocks were determined from differences in clock corrections taken at the same decimal of a day a few days apart, so chosen as to eliminate relative personal equations, and star places from the rate curve. The Riefler clocks are sealed in glass cases under constant pressure, and are kept in the clock vault under constant temperature.

From 3,600 observations of clock stars on 463 nights, in the eight years under discussion, it was found that the clock corrections determined shortly

before sunrise were $0^s.009$ larger than those determined shortly after sunset, on an average 9.5 hours earlier. These results are given in the fourth column of Table I. Taking account of the daily motion in the marks, as given in the fifth column, the true difference in the clock corrections comes out $+0^s.003$, the morning correction being the larger. This is shown in the last column of the table.

TABLE I

	No. Nights	Interval	Morning Minus Evening: Δ Clock Cor.	Δ Az.	Corr'd Δ Clock Cor.
Jan., Feb., Mar.	115	$10^h.1$	$+0^s.005$	$+0^s.011$	$-0^s.006$
Apr., May, June	113	8 .2	+0 .012	+0 .004	+0 .008
July, Aug., Sept.	91	8 .8	+0 .009	+0 .001	+0 .008
Oct., Nov., Dec.	144	10 .7	+0 .008	+0 .002	+0 .006
Means		$9^h.5$	$+0^s.0087$	$+0^s.0055$	$+0^s.0032$

TABLE II

	No. Nights	Morning Minus Evening: Δ Clock Cor.	Δ Az.	Corr'd Δ Clock Cor.
1913	39	$-0^s.003$	$+0^s.001$	$-0^s.004$
1914	70	+0 .013	+0 .006	+0 .007
1915	70	+0 .017	+0 .002	+0 .015
1916	71	+0 .014	+0 .007	+0 .007
1917	32	+0 .015	+0 .011	+0 .004
1918	37	+0 .001	+0 .008	−0 .007
1919	53	+0 .002	0 .000	+0 .002
1920	91	+0 .004	+0 .009	−0 .005
			Mean	$+0^s.003$

A grouping of the same data by years is given in Table II.

This mean value, $+0^s.003$, of the variation in the clock correction, during the night is similar in size but of opposite sign to that, $-0^s.007$, derived from the work of the eight preceding years; and the mean result, $-0^s.002$, from 839 nights, confirms the conclusion of the former paper, that there is practically no daily variation in the clock corrections resulting from work on this instrument in the last eighteen years; and that the clocks have the same rate day and night.

VARIATION OF LATITUDE OBSERVATIONS AT THE U. S. NAVAL OBSERVATORY,

By F. B. LITTELL.

[Communicated by Captain W. D. MacDougall, U. S. Navy, Superintendent .]

The observers during the period 1921.0 — 1922.0 were F. B. Littell and J. D. Wise. Practically all of the plates were measured by Mr. Wise. The program and star list were the same as in the period 1915.9 — 1920.0, the results for which are contained in *A. J.* No. 783.

The scale value was corrected by the results of the observations during the year. The probable error of a latitude from a single star was $\pm 0''.108$, those for the five preceding years ranging from $\pm 0''.086$ to $\pm 0''.098$. The probable error of a latitude for a single night when 13 or more stars were observed was $\pm 0''.034$, those of the five preceding years ranging from $\pm 0''.025$ to $\pm 0''.036$.

The value of the constant of aberration deduced from the closing error for this year is $20''.476$. The separate values for each of the six years covered by this work are given below for comparison. The probable errors of the values for the separate years were deduced from the probable errors of the group differences upon which they depend.

	″	″
1916	20.440	±0.015
1917	20.476	± .013
1918	20.467	± .015
1919	20.413	± .014
1920	20.449	± .015
1921	20.476	± .014
Mean	20.454	±0.007

Table 1 gives the variation of latitude at Washington for each twentieth of the year as deduced graphically from the adopted latitude curve.

TABLE 1

Corrections to Mean Latitude for Washington

	″		″
1920.95	−0.10	1921.50	+0.05
1921.00	− .07	.55	+ .03
.05	− .04	.60	− .01
.10	+ .01	.65	− .05
.15	+ .07	.70	− .10
.20	+ .11	.75	− .15
.25	+ .13	.80	− .17
.30	+ .15	.85	− .16
.35	+ .15	.90	− .14
.40	+ .13	1921.95	− [.11]
1921.45	+ .08	1922.00	− [.09]

Table 2 gives for each observing night, the initial of the observer, the number of stars observed and the resulting observed excess of the latitude of the instrument over +38° 55′ 16″.00 for each group, the mean for the night, and the correction, "v," to reduce the observed latitude to that given by the adopted curve.

TABLE 2

OBSERVED LATITUDES OF THE PHOTOGRAPHIC ZENITH TUBE

Date	Obsr.	No. Obs.		Observed Latitude			v
1921		ii	iii	ii	iii	mean	
				″	″	″	″
Jan. 1.4	W	8	2	0.94	0.88	0.93	+0.03
2.4	W	8	1	1.13	0.98	1.11	− .14
3.4	L	8	8	0.98	0.94	0.96	+ .01
4.4	W	6	2	0.97	0.81	0.93	+ .01
6.4	W	8	8	0.98	1.02	1.00	− .03
10.5	L	.	8	. . .	1.01	1.01	− .03
12.4	L	7	8	1.08	0.91	0.99	− .01
		iii	iv	iii	iv	mean	
17.5	L	8	1	1.07	0.65	1.02	− .03
18.5	W	7	5	1.02	0.89	0.96	+ .03
23.5	W	7	6	1.09	0.84	0.97	+ .03
24.5	L	8	8	1.13	0.97	1.05	− .05
26.5	L	7	5	0.94	0.94	0.94	+ .07
27.5	W	8	8	0.97	0.93	0.95	+ .06
Feb. 3.4	W	2	.	1.23	. . .	1.23	− .20
6.5	W	8	8	1.04	1.00	1.02	+ .02
11.4	W	8	5	1.12	1.07	1.10	− .04
12.4	L	8	8	0.91	1.12	1.01	+ .06
14.4	L	7	8	0.93	1.03	0.98	+ .09

Date	Obsr.	No. Obs.		Observed Latitude			v
1921		iii	iv	iii	iv	mean	
				″	″	″	″
Feb. 15.4	W	8	7	1.02	0.96	0.99	+0.09
16.4	L	8	6	1.13	1.07	1.10	− .02
22.4	W	8	4	1.09	1.24	1.14	− .04
24.4	W	7	8	1.15	1.25	1.21	− .10
		iv	v	iv	v	mean	
Mar. 1.5	L	8	5	1.05	1.18	1.10	+ .02
3.4	W	3	.	1.18	. . .	1.18	− .05
6.5	W	5	6	1.29	1.33	1.31	− .18
7.5	W	5	7	1.11	1.16	1.14	− .01
10.5	W	8	8	1.06	1.11	1.09	+ .05
11.5	L	8	8	1.10	1.20	1.15	− .04
13.5	W	8	6	1.10	1.12	1.14	+ .03
16.5	L	5	8	1.20	1.11	1.14	.00
18.5	L	8	7	1.04	1.29	1.16	− .01
22.4	W	8	.	1.01	. . .	1.01	+ .11
25.5	L	8	8	1.14	1.21	1.17	− .02
26.5	W	8	7	1.12	1.17	1.15	.00
29.5	W	7	7	1.16	1.25	1.20	− .04
Apr. 1.5	W	8	8	1.12	1.18	1.15	+ .01
5.4	W	8	8	1.11	1.15	1.13	+ .03
11.4	L	7	.	1.15	. . .	1.15	+ .02
		v	vi	v	vi	mean	
Apr. 19.6	W	8	8	1.26	1.22	1.24	− .06
21.6	L	7	8	1.19	1.13	1.16	+ .02
May 8.5	L	8	8	1.19	1.27	1.23	− .05
9.5	W	8	8	1.26	1.25	1.26	− .08
16.5	L	8	8	1.23	1.19	1.21	− .04
17.5	W	8	8	1.18	1.08	1.13	+ .04
19.5	W	8	8	1.16	1.22	1.19	− .02
20.5	L	8	8	1.15	1.16	1.15	+ .01
22.4	W	7	3	1.13	1.11	1.13	+ .03
25.4	L	6	1	1.28	1.20	1.27	− .11
26.4	W	6	.	1.22	. . .	1.22	− .06
31.5	W	6	7	1.17	1.16	1.16	− .02
June 2.5	W	6	8	1.22	1.10	1.15	− .01
3.5	L	6	8	1.15	1.09	1.12	+ .02
		vi	vii	vi	vii	mean	
June 5.6	W	7	8	1.12	1.06	1.09	+ .04
9.5	W	7	6	1.14	1.02	1.09	+ .03
10.5	L	6	8	1.14	1.09	1.11	+ .01
12.5	W	7	8	1.20	1.08	1.14	− .03
19.5	W	8	.	1.06	. . .	1.06	+ .01
20.5	L	8	8	1.04	1.05	1.05	+ .05
21.5	W	1	.	1.12	. . .	1.12	− .02

Date	Obsr.	No. Obs.		Observed Latitude			v
1921		vi	vii	vi	vii	mean	
				″	″	″	″
June 24.5	L	8	6	1.17	1.14	1.15	−0.06
26.5	W	7	8	0.98	1.06	1.03	+ .06
July 1.5	L	6	6	1.14	1.03	1.08	.00
2.5	W		6	.	1.06	1.06	+ .02
14.4	W	1		1.18	...	1.18	− .11
16.4	W	8	8	1.14	1.08	1.11	− .05
17.4	W	8		1.06		1.06	.00
18.4	L	8	8	1.03	0.96	0.99	+ .07
23.4	W	7	8	1.03	0.96	*	
24.4	W	8	6	1.09	1.08	*	

*Three groups observed. Mean of all with vii, viii.

Date	Obsr.	No. Obs.		Observed Latitude			v
		vii	viii	vii	viii	mean	
July 19.5	W	7	8	1.08	1.14	1.11	− .05
20.5	L	8	8	1.10	1.16	1.14	− .08
22.4	L	2		1.03	.	1.03	+ .02
23.5	W	8	8	0.96	1.00	1.00*	+ .05
24.5	W	6	4	1.08	1.15	1.10*	− .05
25.5	L	8	3	0.99	1.11	1.02	+ .03
26.5	W	8	8	1.05	1.08	1.07	− .02
31.5	W	8	7	1.06	1.03	1.04	.00
Aug. 1.5	W	8	8	0.99	1.06	1.03	.00
8.4	L	5		0.94		0.94	+ .08
9.5	W	8	8	0.96	1.02	0.99	+ .03
11.4	W	7	4	1.01	0.93	1.00	+ .01
18.4	L	8	8	0.98	1.01	0.99	.00
22.4	L	8	8	1.01	1.01	1.01	− .02
24.4	L	8	7	0.85	0.91	0.88	+ .10

Date	Obsr.	No. Obs.		Observed Latitude			v
		viii	i	viii	i	mean	
Aug. 30.5	W	8	8	1.09	0.98	1.04	− .07
Sept. 8.4	W	6		1.00		1.00	− .05
11.4	L	8		0.90		0.90	+ .03
15.5	W	8	7	1.01	0.93	0.99	− .06
18.4	W	7		0.98	...	0.98	− .06
19.5	L	8	7	0.93	0.91	0.92	.00
22.5	W	8	8	0.92	0.87	0.90	+ .01
23.5	L	8	8	0.90	0.94	0.92	− .01
26.4	L	5		0.93		0.93	− .03
28.4	W	7	8	0.90	1.01	0.96	− .07
29.4	W	5	.	0.85	...	0.85	+ .04
30.4	W	8	8	0.97	0.84	0.90	− .01
Oct. 1.4	W	8	8	0.83	0.85	0.84	+ .01

Date	Obsr.	No. Obs.		Observed Latitude			v
1921		viii	i	viii	i	mean	
				″	″	″	″
Oct. 2.4	W	8	7	0.80	0.71	0.76	+0.12
3.4	W	7	6	0.91	0.90	0.90	− .02
4.4	W	6	.	0.70	...	0.70	+ .17
5.4	L	8	8	0.77	0.77	†	.....
6.4	W	6	8	0.84	0.81	†	.....

†Three groups observed. Mean of all with i, ii.

Date	Obsr.	No. Obs.		Observed Latitude			v
		i	ii	i	ii	mean	
Oct. 5.5	L	8	8	0.77	0.82	0.78†	+ .09
6.5	W	8	7	0.81	0.88	0.84†	+ .03
8.5	W	8	8	0.95	0.95	0.95	− .08
10.5	L	8	8	0.94	0.94	0.94	− .08
13.5	W	8	8	0.88	0.87	0.88	− .02
16.5	W	8	7	0.88	0.93	0.91	− .05
20.4	W	6		0.80	...	0.80	+ .06
21.5	L	8	8	0.83	0.82	0.83	+ .03
24.5	L	8	8	0.75	0.67	0.71	+ .15
25.5	W	8	8	0.89	0.84	0.86	.00
27.4	W	2	.	1.02	...	1.02	− .16
Nov. 1.4	W	3	.	0.93	.	0.93	− .07
4.5	L	8	8	0.91	0.76	0.84	+ .03
5.5	W	7	8	0.83	0.92	0.87	.00
12.4	W	7	8	1.00	0.88	0.93	− .05
15.4	W	8	8	0.79	0.91	0.85	+ .03

Date	Obsr.	No. Obs.		Observed Latitude			v
		ii	iii	ii	iii	mean	
Nov. 21.5	L	7		0.80	...	0.80	+ .09
22.5	W	8	.	0.91	..	0.91	− .02
29.5	L	5	7	0.83	1.04	0.95	− .05
Dec. 3.5	L	7	4	0.95	0.76	0.88	+ .02
18.4	W	8	.	0.96	. .	0.96	− .04
21.5	W	7	6	1.01	1.04	1.02	− .09
27.5	L	8	8	1.00	0.90	0.95	− .02
29.4	L	8	3	0.92	1.23	1.00	− .06
30.4	W	8	8	0.86	0.87	0.87	+ .07
31.4	L	8	2	1.00	0.66	0.93	+ .01
1922 Jan. 1.4	W	6	8	0.88	1.02	0.96	.....
2.4	L	8	5	0.74	0.93	0.84	.....
5.4	L	7	7	0.96	1.04	1.00	.....
6.4	W	7	4	0.89	0.69	0.87	.....
7.4	L	8	8	0.95	0.86	0.91	.....
12.4	L	8	8	0.89	1.00	0.95	.....
13.3	W	3	.	0.98	...	0.98	.....
14.4	L	8	8	0.85	0.94	0.90	.....

CONTENTS.

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OBSERVATIONS OF *JUPITER'S* SATELLITES *VI*, *VII* AND *VIII* AND OF *PHŒBE*,

WITH THE 2-FOOT REFLECTOR OF THE YERKES OBSERVATORY,

By G. VAN BIESBROECK.

The 24-inch reflector, ratio of aperture 1 to 4, was used at full aperture for obtaining plates covering the field of the faint satellites. As far as possible the plates were taken in pairs in immediate succession and the moving objects were then recognised without too much difficulty by means of the blink-comparator. During the exposure allowance was made for the motion of the satellites by shifting the guiding eye-piece by the necessary amounts. Thus the exposure-times were greatly reduced; the satellites appear as round images, the stars as trails, short enough however for easy bisection. The measures were made in rectilinear coördinates with the Gaertner screw-machine, used for stellar-parallax work. The plates were measured in four directions, with three settings on each object, star or satellite. The errors inherent to the peculiar grouping of the silver grains in any faint image are so much larger than the uncertainty of the readings that more settings would have been useless. The satellite was always referred to three nearby small stars of 11^m to 12^m. The positions of these were deduced from astrographic plates taken for this special purpose through the kindness of Mr. G. Lecointe and my colleagues in Uccle (Belgium.) These plates I measured in the same machine. Plate constants for these were computed from 14 to 24 comparison stars, the positions of which were taken from the recent Abbadia catalogues. By means of these constants the standard rectilinear coördinates of the faint reference stars for the satellite were found, and by a linear transformation the measure coördinates on the reflector plate were changed to astrographic standard coördinates. Then the equatorial coördinates for the equinox of the catalogue stars (1900) and finally the positions for the date were computed.

The positions of *Phœbe*, *Jupiter VI* and *VII* given in the *American Ephemeris* were found close enough for locating their field. For *Jupiter VIII* no ephemeris has been published for this opposition but approximate positions, running only as far as March 27 were kindly communicated to the writer by Mr. J. Jackson (Greenwich). The object was found on the first trial plate on April 15, some 50 sec. east and 10′ north of the computed place. No attempt was made to photograph *Jupiter IX* since this would have required long exposures on the best nights, leaving no time for the other objects.

On the nights when I was on duty with the 40-inch refractor the plates were exposed by Mr. O. Struve; his name is indicated by the letter *S* in the column "observers." I took care of the measures and reductions.

1922	Gr. M. T.	α App.	δ App.	Parallax in α	Parallax in δ	Image	Expos. Time	Observer
				Phœbe				
	h m s	h m s	° ′ ″	s	″		m	
Mar. 3	20 8 27	12 23 12.95	+0 21 38.8	+0.01	+0.7	good	36	VB
3	21 39 56	23 11.90	0 21 44.9	+ .03	.7	good	36	VB
Apr. 19	15 10 17	10 43.20	1 43 6.0	− .01	.7	fair	35	S
19	15 49 36	10 42.75	1 43 7.7	− .01	.7	fair	35	S
22	14 53 22	12 10 2.41	+1 47 5.5	− .01	+0.7	poor	30	VB

1922	Gr. M. T.	α App.	δ App.	Parallax in α	Parallax in δ	Image	Expos. Time	Observer
		Jupiter VI						
	h m s	h m s	° ′ ″	s	″		m	
Mar. 2	20 39 0	13 10 37.20	−5 31 21.5	+0.01	+1.4	poor	10	S
2	22 19 0	10 35.39	−5 31 12.7	+ .06	1.4	poor	10	S
3	20 54 2	13 10 16.63	−5 32 11.7	+ .01	1.4	good	36	VB
Apr. 19	16 55 27	12 15 50.59	−3 33 38.3	+0.00	1.1	good	36	VB
19	17 34 14	15 49.85	−3 33 33.6	+ .02	1.1	fair	36	VB
21	17 38 59	11 45.12	−3 28 10.1	+ .02	1.1	poor	30	VB
22	16 19 11	12 11 15.17	−3 25 40.3	− .01	+1.1	good	30	S
		Jupiter VII						
Apr. 19	16 55 27	12 13 31.52	−3 19 41.2	0.00	+1.1	fair	36	VB
19	17 34 14	13 30.76	−3 19 38.2	+0.02	1.1	fair	36	VB
21	17 38 59	12 10.91	−3 15 1.9	+ .03	1.1	poor	30	VB
22	16 19 11	12 18.15	−3 12 57.1	− .01	1.1	fair	30	S
29	18 10 12	39 15.54	−2 58 27.0	+ .05	1.4	fair	40	S
29	18 53 45	12 39 14.94	−2 58 27.1	+ .06	+1.1	poor	40	S
		Jupiter VIII						
Apr. 15	15 16 12	12 58 11.14	−3 47 57.1	−0.05	+1.4	v.ft.	17	S
15	16 4 14	58 10.33	47 50.9	− .03	1.4	fair	45	S
17	17 16 17	57 13.54	41 19.2	+ .02	1.1	fair	15	VB
17	18 32 18	57 12.74	41 12.6	+ .03	1.4	fair	40	VB
22	18 12 27	55 30.25	26 9.3	+ .05	1.4	good	60	S
28	16 31 30	53 3.36	9 13.7	.00	1.4	poor	10	VB
28	17 16 30	53 2.72	9 38.7	+ .02	1.4	fair	10	VB
30	17 3 30	52 16.37	1 29.5	+ .02	1.4	v. ft.	10	S
30	17 15 30	12 52 15.50	−3 1 25.8	+0.01	1.4	fair	10	S

Neglecting the small tabular errors of the planets I find the following corrections to the positions computed from F. E. Ross' elements in the *American Ephemeris* for 1922.

		O − C	
Phœbe	March 3	+0.7	3″
	April 19	+1.3	16
	22	+1.1	15
Jupiter VI	March 2	− 1	1.1′
	3	− 4	−1.1
	April 19	11	−0.1
	21	−12	−0.1
	22	−12	0.0
Jupiter VII	April 19	− 3s	−3.2′
	21	0	−3.2
	22	+ 2	−3.1
	29	+19	−3.2

Williams Bay, Wis.,
Sept. 5, 1922.

OBSERVATIONS OF THE SATELLITES OF *SATURN*, 1913-14,

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

By ASAPH HALL.

[Communicated by CAPT. W. D. MACDOUGALL, U. S. Navy, Superintendent, U. S. Naval Observatory.]

Date		W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
				Rhea-Titan					
1913		h m s	°	h m s					
Oct.	4	14 36 29	256.125	14 37 32	153.47	4 , 4	3 4	367p, Brt.	Windy. Poor observations.
	4	15 22 31	256.069	15 23 22	150.91	4 , 4	3 4	367p, Brt.	
	14	13 2 2	73.751	13 5 30	259.45	4 , 4	3	367b, Brt.	Bright moonlight.
	14	13 53 28	72.953	13 53 36	257.58	4 , 4	3	367b, Brt.	
	26	14 11 39	133.749	14 14 35	145.79	4 , 5	2	388, Brt.	
	26	14 41 6	132.801	14 40 48	147.86	4 , 4	2	388, Brt.	
	28	11 56 34	83.689	11 57 48	267.88	4 , 4	3	388, Brt.	
	28	12 50 42	83.077	12 47 58	265.59	4 , 4	3	388, Brt.	
	29	11 58 49	67.756	11 59 35	163.29	4 , 4	3	388, Brt.	Windy.
	29	12 46 36	67.291	12 49 23	159.55	4 , 4	3	388, Brt.	
	31	11 58 37	70.610	11 58 44	135.99	4 , 4	3	388, Brt.	
	31	12 38 31	70.291	12 38 40	137.81	4 , 4	3	388, Brt.	
Nov.	4	14 57 5	265.750	15 0 23	209.13	4 , 4	2	388, Brt.	
	4	15 39 19	265.375	15 42 46	206.90	4 , 4	2	388, Brt.	
	6	10 30 30	264.148	10 34 13	123.59	4 , 4	2	388, Brt.	Clock ran badly.
	6	11 16 16	264.195	11 18 35	125.27	4 , 4	2	388, Brt.	
	17	12 33 47	318.326	12 36 41	94.10	4 , 4	3 4	367b, Brt.	
	17	13 11 58	317.366	13 12 37	93.65	4 , 4	3 4	367b, Brt.	
	22	13 37 20	249.148	13 37 9	244.48	4 , 4	3	367b, Brt.	
	22	14 19 47	248.591	14 21 8	240.66	4 , 4	3	367b, Brt.	
	24	10 34 51	190.198	10 34 29	64.67	4 , 4	3	388, Brt.	Windy.
	24	11 11 53	190.229	11 12 13	63.79	4 , 4	3	388, Brt.	
Dec.	3	10 23 36	39.800	10 23 54	150.49	4 , 4	3	367b, Brt.	
	3	11 6 15	38.162	11 5 46	148.80	4 , 4	3	367b, Brt.	
	4	11 19 12	317.709	11 21 20	154.43	4 , 4	3 4	367b, Brt.	Windy.
	4	11 52 56	316.219	11 55 35	156.71	4 , 4	3 4	367b, Brt.	
	8	9 54 27	266.938	9 56 38	157.64	4 , 4	3-4	388, Brt.	Windy.
	8	10 33 32	266.839	10 32 7	159.79	4 , 4	3 4	388, Brt.	
	11	10 34 38	154.229	10 33 9	134.17	4 , 4	2-3	367b, Brt.	Moonlight.
	11	11 6 58	152.543	11 8 18	135.07	4 , 4	2 3	367b, Brt.	
	13	10 26 25	101.377	10 28 22	119.74	4 , 4	2-3	388, Brt.	Moonlight.
	13	11 1 25	101.344	11 4 0	118.44	4 , 4	2 3	388, Brt.	
	15	10 25 17	98.905	10 28 19	211.63	4 , 4	2	367b, Brt.	
	15	10 56 57	98.591	10 58 1	214.15	4 , 4	2	367b, Brt.	
	19	12 59 50	316.852	13 1 57	73.54	4 , 4	3	388, Brt.	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
				Rhea-Titan (Continued)				
1913	h m s	°	h m s	″				
Dec. 19	13 22 6	316.796	13 21 26	72.80	4 , 4	3	388, Brt.	
27	11 19 53	219.528	11 19 26	99.07	4 , 4	2	367*b*, Brt.	Haze.
27	12 21 28	218.929	12 29 31	99.77	4 , 4	2	367*b*, Brt.	
30	8 58 6	91.770	9 0 31	276.68	4 , 4	2	367*b*, Brt.	
30	9 37 25	91.293	9 10 32	276.33	4 , 4	2	367*b*, Brt.	
1914								
Jan. 5	9 8 48	301.518	9 9 18	173.65	4 , 4	3-4	367*b*, Brt.	
5	9 13 30	303.385	9 14 5	176.23	4 , 4	2-3	367*b*, Brt.	
8	10 3 56	269.651	10 6 17	118.21	4 , 4	3	367, Brt.	
8	10 18 21	269.824	10 50 28	119.66	4 , 4	3	367, Brt.	Moonlight. Haze.
13	7 19 1	108.259	7 18 32	146.35	4 , 4	3	367*b*, Brt.	
13	7 58 11	107.799	8 4 16	145.38	4 , 4	3	367*b*, Brt.	Clouds.
14	8 31 20	108.906	8 34 28	93.74	4 , 4	2	367, Brt.	Haze.
22	8 7 50	312.360	8 7 34	121.19	4 , 4	2	388, Brt.	Brightness changing occasionally. Haze.
27	8 56 53	230.270	8 59 30	79.12	4 , 4	3	388, Brt.	Clouds.
29	10 3 47	146.107	9 59 42	133.11	4 , 4	3-4	367*b*, Brt.	Too poor to continue.
Feb. 2	8 36 55	78.191	8 40 49	111.22	4 , 4	3	495, Brt.	Haze.
2	9 49 15	78.969	9 51 28	112.19	4 , 4	2	388, Brt.	Haze.
3	9 55 10	77.303	9 58 17	172.95	4 , 4	2-3	367*b*, Brt.	
3	11 2 25	76.767	11 8 33	175.73	4 , 4	2-3	367*b*, Brt.	Clouds.
4	9 3 18	58.192	9 6 56	179.73	4 , 4	2	367*b*, Brt.	Moonlight. Haze.
4	9 12 54	57.321	9 50 40	178.20	3 , 4	2	367*b*, Brt.	Stopped by clouds.
7	10 21 14	272.068	10 27 20	171.73	4 , 4	2-3	367*b*, Brt.	
17	9 3 18	90.300	9 2 30	263.82	4 , 4	3	367*b*, Brt.	
17	9 14 31	89.799	9 16 39	265.82	4 , 4	3	367*b*, Brt.	
21	9 8 1	273.631	9 9 3	257.88	4 , 4	3	388, Brt.	
21	9 11 9	273.115	9 13 15	258.86	4 , 4	3	388, Brt.	
26	8 31 51	233.710	8 36 33	119.85	4 , 4	3	388, Brt.	
26	9 8 50	233.237	9 8 22	118.15	4 , 4	3	388, Brt.	
27	9 15 15	228.952	9 17 1	69.64	4 , 4	2	388, Brt.	
27	10 1 50	229.140			2 , 0	2	388, Brt.	Stopped by haze. Rhea ft.
Mar. 1	7 11 52	85.011	7 15 58	201.13	4 , 4	3	388, Brt.	
				Titan-Hyperion (p and s)				
1913								
Oct. 5	14 50 31	28.335	14 51 18	143.20	4 , 4	2	367*b*, Red	
5	15 38 36	26.872	15 40 14	141.67	4 , 4	2	367*b*, Red	
Nov. 1	15 27 14	238.792	15 27 57	301.31	4 , 4	2-3	367*b*, Red	
1	16 28 1	237.953	16 31 51	298.27	4 , 4	2-3	367*b*, Red	
2	11 59 10	222.625	12 3 19	229.07	4 , 4	1	367*b*, Red	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
			Titan-Hyperion (p and s) (*Continued*)					
1913	h m s	°	h m s	″				
Nov. 2	12 54 52	221.694	12 55 43	226.33	4 , 4	1	367*b*, Red	
4	12 5 36	149.296	12 6 49	164.59	4 , 4	2	367*b*, Red	
4	13 4 34	147.459	13 3 38	166.36	4 , 4	2	367*b*, Red	
5	11 39 59	121.266	11 41 37	205.45	4 , 4	1–2	367*b*, Red	Hyperion faint. Haze.
5	12 36 15	120.465	12 42 4	207.54	4 , 5	1–2	367*b*, Red	
6	12 29 31	104.308	12 33 11	217.28	4 , 4	2	367*b*, Red	
6	13 30 50	103.869	13 33 5	219.00	4 , 4	2	367*b*, Red	
20	10 33 6	251.135	10 36 0	93.49	4 , 4	3	388, Red	Hyperion very faint.
20	11 15 42	251.198	11 15 38	92.54	4 , 4	3	388, Red	
21	9 42 41	250.755	9 41 31	71.60	4 , 4	2	388, Red	Apparently a little fog.
21	10 11 26	250.749	10 12 3	71.59	4 , 4	2	388, Red	
22	9 49 17	255.012	9 50 52	63.18	4 , 4	2	388, Red	A little fog.
22	10 20 57	254.863	10 21 42	62.83	4 , 4	2	388, Red	
24	13 26 51	261.093	13 28 17	84.85	4 , 4	3	388, Red	
24	14 4 4	261.268	14 5 10	85.29	4 , 4	3	388, Red	
Dec. 4	10 28 5	87.395	10 30 16	203.59	4 , 6	3	367*b*, Red	Hyperion very faint. Windy.
5	13 24 41	75.751	13 29 5	212.01	4 , 4	2 3	367*b*, Red	Hyperion very faint.
5	14 21 36	75.375	14 23 37	210.83	4 , 4	2 3	367*b*, Red	
9	10 59 14	334.161	10 58 3	150.90	4 , 4	2	367*b*, Red	Very faint. Moonlight
9	11 34 13	333.427	11 41 1	151.73	3 , 5	2	367*b*, Red	
9	13 50 43	329.798	13 48 47	155.72	4 , 4	2	367*b*, Red	Very ft. Moonlight. Haze.
9	14 25 22	329.109	14 25 48	157.13	4 , 4	2	367*b*, Red	
15	12 3 3	254.034	12 2 59	401.54	4 , 4	2–3	367*b*, Red	
15	13 5 42	253.613	13 9 36	400.63	4 , 4	2–3	367*b*, Red	
19	10 0 20	156.233	10 8 8	203.95	4 , 4	2	367*b*, Red	Hyperion faint.
19	10 46 2	154.879	10 45 40	205.02	4 , 4	2	367*b*, Red	
1914 29	13 17 32	294.022	13 22 15	335.29	4 , 4	2	367*b*, Red	
Jan. 15	10 11 11	339.670	9 58 17	106.86	4 , 4	2–3	367*b*, Red	
15	11 8 27	338.221	11 9 58	106.98	4 , 4	2–3	367*b*, Red	Hyperion very faint.
17	9 42 34	289.460	9 48 17	175.78	4 , 4	3	367*b*, Red	Hyperion very ft. Windy.
29	8 49 45	250.879	8 46 53	104.72	4 , 4	3	367*b*, Red	Hyperion very faint. Too poor to continue.
Feb. 21	8 5 42	147.881	8 4 6	197.31	4 , 4	2	367*b*, Red	Hyperion very faint.
21	8 59 24	146.406	9 3 40	199.89	4 , 4	2	367*b*, Red	
			Titan-Japetus (p and s)					
1913								
Oct. 13	12 42 29	11.422	12 39 53	162.57	4 , 4	3 4	388, Brt.	
13	13 29 54	11.271	13 31 39	161.17	4 , 4	3 4	388, Brt.	*Japetus* faint.
16	14 12 36	38.979	14 14 6	108.43	4 , 4	3	388, Brt.	Clouds.
16	14 56 25	39.491	14 58 28	109.08	4 , 4	3	388, Brt.	
22	12 9 36	355.300	12 7 33	175.87	4 , 4	2–3	367*b*, Brt.	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
			Titan-Japetus (p and s) (*Continued*)					
1913	h m s	°	h m s	"				
Oct. 22	[illegible] 0 28	274.016	12 59 35	176.63	1 , 4	2 3	367b, Brt.	
Nov. 20	12 17 10	192.157	12 16 51	224.85	1 , 4	2 3	388, Brt.	Clock ran badly.
20	12 59 32	192.005	13 0 50	223.05	4 , 4	2 3	388, Brt.	
21	12 49 55	171.591	12 50 45	177.55	1 , 1	2	388, Brt.	Fog. Moonlight.
21	13 50 57	175.902	13 51 45	175.76	1 , 4	2	388, Brt.	
22	11 35 45	160.996	11 36 54	145.63	4 , 1	2	367b, Brt.	
22	12 12 58	160.671	12 15 27	144.60	4 , 1	2	367b, Brt.	
24	11 14 6	156.681	11 13 55	84.41	4 , 4	3	388, Brt.	Windy.
24	12 9 18	157.102	12 11 32	83.71	4 , 4	3	388, Brt.	
Dec. 29	10 2 9	26.873	10 2 0	301.09	4 , 4	2	367b, Brt.	
30	7 18 20	13.605	7 18 10	243.33	4 , 4	2	367b, Red	
1914 30	8 24 23	13.441	8 25 47	241.64	4 , 4	2	367b, Red	Haze. Fog.
Jan. 5	13 15 55	32.991	13 18 45	98.26	4 , 1	3	367b, Brt.	
5	13 51 20	33.194	13 53 10	98.90	4 , 4	3	367b, Brt.	
7	8 22 46	34.287	8 22 18	132.12	4 , 4	2 3	367b, Brt.	
7	8 52 27	34.057	8 53 26	132.33	4 , 4	2 3	367b, Brt.	*Japetus* faint at last. Moonlight. Haze.
Feb. 7	8 59 36	191.371	8 59 40	238.28	4 , 4	3	367b, Brt.	
7	9 45 54	190.824	9 46 6	236.68	4 , 4	3	367b, Brt.	
9	9 51 7	151.134	9 54 38	174.12	4 , 1	3	367b, Brt.	
9	10 30 50	150.704	10 30 19	173.58	4 , 4	3	367b, Brt.	
Feb. 12	9 1 49	129.492	9 3 57	96.92	4 , 4	3	388, Brt.	
12	9 31 1	129.567	9 34 52	96.64	4 , 4	3	388, Brt.	
17	7 34 41	160.341	7 35 48	105.90	4 , 4	3	388, Red	
17	8 21 36	159.742	8 24 17	106.62	4 , 4	3	388, Red	
Mar. 1	9 54 24	68.376	9 56 28	389.11	4 , 4	3	388, Red	
7	8 0 0	77.198	8 3 1	411.11	4 , 4	3	388, Red	
7	8 51 32	77.217	8 54 24	412.32	4 , 4	3	388, Red	Moonlight.

Date	W. M. T.	$\Delta\alpha$	$\Delta\delta$	Comp.	Seeing	Power and Illum.	Remarks
		Titan-Hyperion (by transits)					
	h m s	s	"				
1913 Oct. 21	13 33 39	+28.460	+ 88.41	t30 , 10	2 3	367b, Red	Hyperion very faint.
21	14 15 0	+28.410	+ 89.82	t30 , 10	2 3	367b, Red	Hyperion very faint.
22	14 25 20	+22.738	+145.60	t30 , 10	2 3	367b, Red	
29	14 13 25	−32.207	− 17.30	t30 , 8	3	367b, Red	Windy.
		Titan-Japetus (by transits)					
1913 Oct. 26	13 44 33	−33.328	+110.28	t29 , 10	2	388, Brt.	
28	13 49 26	−13.625	+ 11.47	t30 , 10	3	388, Brt.	*Japetus* faint at times.

Date	W.M.T.	$\Delta\alpha$	$\Delta\delta$	Comp.	Seeing	Power and Illum.	Remarks
			Titan-Japetus (by transits) (*Continued*)				
	h m s	s	$''$				
1913 Oct. 29	15 9 31	−45.533	− 38.80	t30, 10	3	388. Brt.	
31	15 14 44	−42.218	−148.09	t30, 10	3	388. Brt.	
Nov. 1	13 11 0	−38.576	−137.79	t30, 10	2	367*b*. Brt.	
2	15 11 48	−33.651	−145.14	t30, 10	1–2	367*b*. Brt.	
5	14 46 58	−26.000	− 98.42	t30, 10	2	388. Brt.	
Dec. 5	11 10 2	−40.782	− 71.23	t30, 10	2–3	367*b*. Brt.	*Japetus* very faint.
8	12 54 32	−50.489	+ 86.01	t30, 10	3–4	367*b*. Brt.	*Japetus* faint.
11	9 33 45	+41.340	+174.47	t30, 10	2–3	367*b*. Red	Moonlight.
13	13 6 28	+31.988	+169.58	t30, 10	2–3	388. Brt.	*Japetus* very faint at last.
18	12 11 35	+36.162	+ 86.93	t30, 10	2–3	388. Brt.	*Japetus* faint. [Moonlight.
19	12 14 28	+41.106	+ 91.31	t30, 10	2	367*b*. Brt.	
1914 Jan. 15	8 9 27	−44.146	+ 29.43	t20, 10	3	388. Brt.	Clouds.
28	7 22 35	−37.455	− 86.12	t30, 10	2–3	388. Brt.	
Feb. 2	10 35 47	−39.917	−245.87	t15, 6	–	388. Brt.	The time of $\Delta\delta$ is $10^h 55^m 51^s$. [Stopped by haze.
3	8 40 24	−31.619	−269.02	t30, 10	2–3	388. Brt.	*Japetus* ft. at times. Clouds.

Seeing: 1 = excellent, 2 = good, 3 = fair, 4 = poor. Power and illum.: *p* = prism, *b* = occulting bar over planet, Brt. = bright field, Red = red wires.

Clark II micrometer was used. Value of one revolution = $9''.9329 + 0''.0000\,525(t^\circ - 50^\circ \text{ F.}) + 0''.0255$ ($1^{\text{in.}}.280$-focal scale).

U. S. Naval Observatory, Washington, D. C.,
1922, Sept. 22.

TABULAR ERRORS OF THE *MOON'S* LONGITUDE.

(Communicated by the Astronomer Royal.)

DR. E. W. BROWN contributed a paper to the *Astronomical Journal*, No. 799, in which he compared the Greenwich observations of the *Moon* from 1900 to 1920 with his new tables, and also with these corrected for a term δT which arises from an increase in the assumed secular acceleration, and some other consequential changes.

The Greenwich observations for this period have now been revised:

(1) by applying nine periodic terms, given below, to the tabular (HANSEN-NEWCOMB) places.

(2) by incorporating the observations with the altazimuth in addition to those with the transit-circle, from 1901 to 1905; they had already been incorporated from 1905 onwards.

(3) by correcting a small systematic error that had been made in the reductions of the observations of Mösting A with the transit-circle from 1909 to 1916, and an error in the altazimuth reductions in azimuth 60° which terminated in 1914. (See Greenwich Observations 1916 p. A. 58.)

Periodic terms applied to tabular places; these terms are discussed in *Monthly Notices* of the Royal Astronomical Society, November and December 1903.

$$
\begin{aligned}
&+1''.56 \sin D \\
&- \quad .893 \sin (g + 2\,\varpi - 2J) \\
&- \quad .676 \sin (g + 2 \quad + 3\,v - 5\,E) \\
&- \quad .548 \sin g \\
&- \quad .246 \sin (2\,D - g) \\
&+ \quad .55 \;\; \sin g' \\
&- \quad .55 \;\; \sin (g - D) \\
&+ \quad .316 \sin (g + 2\,\varpi - 3\,J + 7^\circ) \\
&+ (\Delta g + 4''.06 \sin \Omega)\, 2\,e \cos g
\end{aligned}
$$

Some of these coefficients might be improved. Thus the $-''.893$ term should be altered to $-1''.137$, and the coefficient of T^2 in the formula for Δg should be

altered from 4″.74 to +0″.83 to reduce to BROWN's theoretical value. DR. COWELL's values have, however, been retained, in order to make the present reductions continuous with his, which extended to 1901 June 18.

The following table gives the old and new values of O and *Th*-O; the latter is the quantity that added to δT gives the total correction required by BROWN's tabular longitude.

	O			Th — O		
Date	Old	New	New (restricted)	Old	New	New (restricted)
	″	″	″	″	″	″
1901.5	− 2.77	− 2.39	− 1.96	−1.80	−2.18	−2.61
2.5	3.15	3.44	2.14	−1.31	−1.02	−2.32
3.5	3.08	3.13	2.70	−1.46	−1.41	−1.84
4.5	3.16	4.16	3.23	−2.06	−1.06	−1.99
5.5	5.29	5.43	5.70	−0.29	−0.15	+0.12
6.5	5.91	5.58	6.13	+0.63	+0.30	+0.85
7.5	5.96	5.55	5.28	+0.95	+0.54	+0.27
8.5	5.97	6.08	6.37	+0.59	+0.70	+0.99
9.5	6.44	6.17	6.69	+0.46	+0.52	+0.74
1910.5	7.85	7.85	7.69	+1.57	+1.57	+1.41
11.5	8.34	8.38	8.57	+1.64	+1.68	+1.87
12.5	9.79	9.84	9.84	+2.01	+2.06	+2.06
13.5	11.93	11.73	11.74	+3.15	+2.95	+2.96
14.5	12.86	12.49	12.42	+3.87	+3.50	+3.43
1915.5	12.58	12.57	12.30	+3.63	+3.62	+3.35
16.5	14.05	13.53	13.40	+4.72	+4.20	+4.07
17.5	14.03	13.85	14.03	+4.59	+4.41	+4.59
18.5	14.05*	13.06	13.10	+4.92*	+3.93	+3.97
19.5	12.26	12.44	12.64	+3.35	+3.53	+3.73
1920.5	−13.11	12.84	12.97	+4.10	+3.83	+3.96
21.5		−12.94	−12.61	+4.46	+4.02	+3.69

These are the values as previously printed, but they should have been −13″.05, +3″.92 respectively.

The column headed "restricted" is limited to the days for which *D*, the *Moon's* mean elongation from the *Sun*, lies between 120° and 240°.

ORBIT OF THE *PONS-WINNECKE* COMET,

BY FRANK E. SEAGRAVE.

The following orbit elements of the *Pons-Winnecke* comet were computed from three observations by WOOD and WORSSELL at Johannesburg, July 4.55607, Aug. 3.54653, and Sept. 4.38353, G. M. T., 1921, — after perihelion. These observations are taken from Union Observatory Circular No. 54. For the sake of comparison, the writer's elements, based upon observations by BARNARD at the same apparition, but before perihelion, are repeated from *A. J.* 790. The perihelion distance is increasing all the time. In 1892 it was $q = 0.8865$, in 1898 $q = 0.9241$, and in 1921 $q = 1.0409$, well outside the *Earth's* orbit. Times are G. M. T., 1921.

ELEMENTS

	Before Perihelion	*After Perihelion*
E	May 31.75350	Aug. 3.53011
M	357° 59′ 48″.71	8° 25′ 0″.13
ω	170 17 18 .07	170 15 56 .16
π	268 23 46 .87	268 24 14 .95
☊	98 6 28 .80	98 8 18 .79
i	18 54 36 .84	18 56 32 .61
log e	9.835212	9.836481
log a	0.518022	0.520822
log q	0.017372	0.017409
μ	592″.888	587″.184
P	2185.909 *d.*	2207.147 *d.*

CONTENTS.

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DECLINATIONS OF 526 STARS,

By SAMUEL G. BARTON.

The following declinations were determined with the Wharton reflex zenith tube of the Flower Observatory which is described in the Publications of the Observatory, Vol. III, Part 1. The instrument was used in the usual manner assuming the latitude known. The corrections for the variation of latitude found in *A. N.* 4802, 4858 and 4908 were applied. All of the stars have declinations between 39° and 41° and are found in the *A. G. Catalogues Bonn* or *Lund*, frequently both. The observations were made in the years 1913–6.

The columns give respectively the *A. G.* numbers, the *A. G.* magnitude, R. A. to nearest second, the observed R. A. reduced to 1875 with the *A. G.* constants disregarding proper-motion, the difference observed minus *A. G.* using the mean of the *A. G.* declinations for stars in both catalogues, the epoch of observation, the resulting computed proper-motion, and the number of observations. When the star is contained in Boss *P. G. C.* or *Cincinnati Observatory Publications* No. 18 or the list of PROF. C. L. DOOLITTLE, *Publications of the Flower Observatory*, Vol. III, Part 1, the fact is noted.

Bonn	*Lund*	Mag.	R. A. 1875.0	Dec. 1875.0	Diff.	Ep.	μ′	n
			h m s	° ′ ″	″		″	
	3	8.7	0 0 33	39 38 21.04	+0.94	15.3	+.027	7
	11	8.8	1 18	53 41.49	−0.31	15.7	−.010	3
	17	7.2	2 22	47 55.82	−0.68	15.1	−.020	8
	30	8.9	4 23	52 55.11	−0.99	15.2	−.029	4
	33	8.7	5 1	54 30.73	+0.63	15.5	+.018	3
	36	7.8	5 2	42 12.16	−0.44	15.0	−.012	5
	58	8.2	7 27	13 29.15	−0.55	15.1	−.016	6
	126	9.4	16 55	44 10.36	−0.98	15.3	−.028	7
	150	8.4	20 8	19 34.56	−0.96	15.2	−.027	6
	160	8.8	24 10	18 41.41	+0.10	15.6	+.003	4
	179	9.1	23 16	10 40.31	−0.39	15.7	−.010	3
	215	8.5	28 54	45 41.00	−0.40	15.5	−.011	4
	218	8.8	29 7	12 28.68	−0.02	15.7	−.001	4
	234	7.5	30 42	38 38.49	−0.21	15.3	−.006	7
	241	8.7	31 52	44 59.32	−0.78	15.5	−.022	4
	245	8.8	32 3	41 37.28	−0.92	15.5	−.026	5
	280	8.6	36 44	42 59.94	−1.36	15.8	−.039	3
	285	7.9	37 46	14 57.34	−1.26	15.5	−.036	6
	294	8.5	39 3	34 3.62	−0.78	15.5	−.020	4
	298	8.8	39 24	14 29.15	−0.95	15.2	−.027	4
	315	8.9	42 38	37 2.99	−0.94	15.7	−.025	5
	340	6.9	45 59	33 52.03	+2.13	15.3	+.061	7
	365	8.2	48 31	42 16.39	−1.04	15.3	−.029	5
	375	8.7	50 9	52 19.44	−1.39	15.5	−.039	4
	381	9.0	1 51 5	39 50 13.39	−1.61	15.8	−.045	2
	387	9.2	51 45	43 49.82	+0.22	14.8	+.006	3
	422	8.8	51 50	54 1.83	−0.77	15.2	−.022	2
	435	8.9	56 49	49 42.68	−1.02	15.1	−.038	3
936	468	8.5	1 9	59 28.99	−3.71	15.1	−.112	5
	478	8.5	2 7	44 21.04	−0.66	15.5	−.019	4
	487	8.6	2 51	47 41.18	−1.22	15.8	−.035	4
1055	531	8.3	9 6	59 16.98	−0.57	15.1	−.016	8
	540	9.1	9 33	48 29.52	−1.78	14.8	−.052	2
1159	577	7.6	16 0	57 20.68	−0.22	15.3	−.006	5
	602	8.3	18 1	39 41.67	+0.27	15.5	+.008	4
	611	8.6	18 50	41 37.35	−1.15	15.6	−.033	6
	615	8.7	19 26	53 19.15	−1.15	15.5	−.033	4
	621	6.1	20 32	41 10.84	−0.76	15.2	−.022	7
	642	8.8	23 36	40 41.80	−0.30	15.2	−.009	4
	699	9.1	30 1	56 53.42	+0.72	14.8	+.021	3
	710	8.0	31 19	38 12.17	−0.83	15.2	−.024	6
1118	736	5.5	33 13	56 34.36	−0.29	15.8	−.010	4
	752	6.8	35 15	44 42.88	−0.62	15.3	−.018	5
	798	8.7	41 12	10 21.94	−1.36	15.9	−.039	3
	802	8.6	42 41	50 35.42	−0.38	15.8	−.011	3
	809	8.6	43 21	16 38.11	−0.79	15.0	−.023	4
	818	8.2	47 10	40 13.92	−0.88	15.1	−.025	6
	861	8.9	47 57	49 51.54	−0.56	15.2	−.019	5

Bonn	Lund	Mag.	R. A. 1875.0	Dec. 1875.0	Diff.	Ep.	μ'	n
			h m s	° ′ ″	″		″	
1683	900	8.6	1 50 52	39 55 10.38	+0.58	15.5	+.016	4
1699	916	8.0	52 6	57 20.86	+0.21	15.6	+.006	5
	919	8.5	56 10	54 5.85	−0.55	15.3	−.019	6
	980	8.6	58 59	40 0 0.82	+0.32	15.5	+.009	7
	998	8.6	1 4	39 53 50.89	−0.61	14.8	−.022	5
	1015	8.6	2 15	11 39.48	+1.38	15.8	+.039	3
	1043	7.9	5 2	40 4.28	−0.42	15.1	−.012	6
	1052	7.2	5 33	55 18.25	−3.25	15.6	−.091	4
	1111	7.8	2 10 55	41 59.74	−0.36	15.4	−.012	5
	1122	8.4	12 56	53 24.37	−0.43	15.7	−.012	3
	1183	8.8	19 10	40 55.19	−0.84	15.2	−.023	6
	1215	7.4	22 53	36 36.98	−0.82	15.4	−.024	7
	1232	7.3	24 31	43 4.35	−0.45	15.2	−.015	5
	1248	8.4	26 30	44 30.38	−0.12	15.4	−.003	5
	1252	8.7	27 35	43 50.99	−2.31	15.9	−.065	3
	1267	7.4	28 28	39 25.98	−0.22	15.0	−.006	6
	1296	8.5	30 38	55 18.35	0.37	15.3	−.010	4
	1323	8.3	32 47	34 38.86	−0.64	15.7	−.018	2
	1339	5.5	34 22	39 12.20	−1.80	15.6	.183	6
	1344	8.5	34 35	43 12.84	−0.46	15.9	−.016	3
	1346	7.6	34 36	13 32.76	−1.04	15.1	−.030	4
2406	1420	8.8	41 41	59 44.05	−0.60	15.5	.016	3
2411	1422	7.8	41 49	57 25.48	−0.37	15.8	.010	4
	1450	8.2	43 50	37 9.93	−0.47	15.2	−.005	6
	1506	8.4	49 2	44 14.03	−0.27	15.0	−.008	6
	1523	8.9	51 20	17 16.29	−1.74	15.6	−.059	4
2549	1543	7.4	52 53	55 9.12	+0.57	14.9	+.016	8
	1548	8.7	53 24	45 54.51	−0.59	15.9	−.016	2
	1551	8.0	53 34	51 59.84	−0.09	16.0	−.002	2
	1572	6.9	56 24	48 6.89	−0.84	15.8	−.022	4
	1587	8.5	57 52	45 10.64	−0.36	15.5	−.010	3
	1595	8.0	59 15	43 2.98	−0.62	16.0	−.017	3
	1601	8.0	59 34	36 4.71	−0.79	16.0	−.022	3
	1658	8.4	3 5 23	40 55.64	−0.89	15.9	−.025	6
	1668	8.4	5 57	43 53.69	−1.11	15.8	−.031	2
	1669	7.0	6 4	38 57.48	−1.02	15.6	−.029	5
	1709	9.0	11 0	42 19.76	−0.64	14.5	−.023	2
	1740	8.3	11 57	43 3.14	+0.01	15.9	.000	4
	1750	7.2	16 16	35 51.36	−0.84	15.1	−.024	6
	1753	7.2	16 46	46 38.47	+1.47	15.4	+.042	6
	1754	8.6	16 54	12 22.79	−0.54	15.9	−.014	2
	1785	6.8	20 17	44 4.01	−1.09	15.3	−.031	8
	1793	7.3	20 44	45 1.22	−0.08	15.5	−.002	5
3011	1850	7.5	26 20	52 58.85	+0.20	15.6	+.006	6
3020	1859	8.5	27 9	56 29.34	−0.26	15.9	−.008	3
	1874	7.0	29 7	40 27.12	+0.02	14.7	+.001	6
	1934	7.2	36 15	40 56.84	−1.16	14.8	−.033	10
3182	1953	9.2	40 10	50 28.33	−0.17	15.3	−.014	4
3222	1973	8.4	43 12	52 16.95	−0.70	15.1	−.024	5
3225	1978	7.6	44 11	59 15.56	+0.81	15.5	+.022	5

Bonn	Lund	Mag.	R. A. 1875.0	Dec. 1875.0	Diff.	Ep.	μ'	n
			h m s	° ′ ″	″		″	
	2034	8.8	3 51 10	39 39 21.76	−1.64	14.1	−.055	2
	2040	7.4	51 47	39 18.32	−0.78	15.1	−.025	5
3341	2047	8.5	52 5	50 41.15	−0.60	15.9	−.018	3
	2054	7.0	52 52	44 25.10	−2.50	15.9	−.070	3
	2062	7.3	53 23	38 5.02	−1.08	15.4	−.031	4
3374	2098	7.6	57 2	57 26.32	−0.58	14.9	−.016	8
	2127	7.5	4 0 44	49 45.18	−3.52	14.8	−.141	9
3450	2147	8.4	3 43	56 44.97	−1.23	15.0	−.041	6
3468	2158	8.0	4 36	40 2 6.94	−0.36	15.8	−.010	3
	2160	8.7	5 4	39 45 36.31	−0.59	16.0	−.019	3
	2178	8.8	7 3	51 31.53	−4.17	15.9	−.153	3
	2182	7.8	8 11	42 42.54	−0.86	15.0	−.033	4
3521	2189	8.9	9 18	56 32.47	+0.27	14.9	+.008	4
	2218	7.0	13 31	38 10.70	−4.20	15.1	−.145	9
3620	2244	8.3	18 30	40 0 46.11	−2.31	15.9	−.070	5
	2264	8.0	22 43	39 52 11.17	−0.23	14.4	−.009	8
	2270	6.9	22 52	44 9.65	−1.05	15.2	−.034	7
	2274	8.3	23 45	39 10.00	1.60	15.4	−.045	5
	2287	8.7	25 33	49 51.32	−1.08	16.0	−.038	3
3737	2305	8.3	29 3	40 2 30.08	−2.32	15.2	−.069	6
3791	2336	8.4	35 8	39 58 56.74	+0.09	14.9	+.002	7
3834	2357	6.5	38 7	40 4 56.90	−0.70	15.0	−.022	5
3843	2362	8.6	39 6	0 15.03	−0.37	15.4	−.011	5
	2399	8.0	45 19	39 17 44.21	−0.49	15.1	−.014	10
	2410	8.3	46 30	44 53.86	−1.24	15.6	−.035	4
3972	2417	8.1	47 53	57 58.72	+0.17	15.7	+.005	5
3989	2431	7.1	49 34	51 40.45	−3.55	15.0	−.107	7
3998	2435	8.6	50 8	40 31 3.33	+0.98	15.1	+.037	6
4002	2437	8.3	50 21	39 52 58.73	−0.52	15.4	−.015	4
4028	2452	7.2	52 2	40 2 29.76	+0.56	16.0	+.017	2
4076	2478	8.0	54 48	39 53 38.47	−0.83	14.8	−.025	7
	2486	8.4	55 59	47 25.43	−0.47	15.8	−.013	5
4122	2500	8.0	57 47	51 50.24	−0.76	15.5	−.022	4
	2515	8.2	59 12	16 29.12	−0.28	15.9	−.008	3
4167	2544	8.4	5 1 19	59 21.62	−0.38	15.8	−.011	6
	2564	8.7	3 14	47 15.09	−0.41	15.3	−.012	3
4205	2566	8.6	3 20	40 0 19.67	−3.23	14.9	−.100	3
4214	2568	6.6	3 34	39 56 41.59	+0.29	14.4	+.008	5
4233	2574	7.6	4 32	40 2 22.85	−0.35	15.3	−.009	3
4270	2596	8.4	6 29	39 59 3.47	+0.47	15.8	+.013	3
4336	2637	4.9	10 21	58 40.98	−19.52	15.2	−.660	7
4405	2689	8.7	14 45	40 1 48.62	−1.23	15.9	−.032	3
4458	2728	9.0	18 56	39 55 59.10	−1.50	15.4	−.046	6
	2768	8.0	21 57	43 36.21	−1.29	14.9	−.037	4
	2769	6.3	22 3	43 30.21	−1.89	15.3	−.054	3
4498	2771	7.8	22 20	55 50.22	−0.33	15.5	−.009	5
	2806	8.7	26 26	15 52.00	−2.60	15.4	−.074	4
4582	2817	8.1	27 28	40 5 8.18	−2.52	15.6	−.063	5
4619	2846	8.6	29 56	39 51 45.18	−1.92	15.0	−.056	5
	2859	8.0	31 48	48 35.31	−0.69	15.3	−.019	7

Bonn	Lund	Mag.	R. A. 1875.0	Dec. 1875.0	Diff.	Ep.	μ'	n
			h m s	° ' "	"		"	
4636	2862	8.8	5 31 28	39 52 22.42	+0.17	15.9	+.005	2
	2865	7.8	31 50	45 48.24	−1.96	15.5	−.055	1
4678	2889	8.4	34 34	51 31.57	−0.28	15.0	−.009	6
4737	2936	8.5	40 4	51 52.07	+1.27	15.1	+.035	7
4741	2939	8.2	40 43	40 7 9.01	−0.84	15.9	−.021	4
4759	2953	8.0	41 30	3 39.05	+0.20	16.0	+.005	3
4854	3017	8.2	48 46	39 56 54.60	−0.95	15.8	−.026	8
4877	3031	7.1	50 32	40 4 5.79	−0.20	15.2	−.007	5
4903	3042	7.2	51 37	39 51 51.88	−0.57	15.2	−.016	5
4965	3071	8.7	55 42	58 8.72	−1.18	15.1	−.033	5
	3106	8.4	58 10	49 19.79	−1.44	15.5	−.040	4
5110	3178	7.1	6 0 32	58 44.10	0.24	14.8	−.007	8
5139	3200	7.2	8 52	53 55.10	0.04	16.0	−.018	4
5146	3205	8.0	9 14	57 0.12	−0.67	16.0	−.020	2
5160	3228	[illegible]	10 53	51 57.10	2.97	14.7	−.080	1
5214	3280	7.8	17 27	59 13.17	1.47	14.7	.037	8
	3296	7.2	17 57	44 30.70	1.50	15.2	.045	5
5260	3299	8.2	18 53	51 32.57	5.08	15.5	[illegible]	1
5296	3322	8.8	21 52	58 18.67	1.10	15.0	.030	4
5298	3335	6.9	22 21	50 10.04	2.36	15.1	.076	5
5328	3357	7.5	24 18	52 17.03	+0.08	15.3	−.002	5
5345	3371	8.0	26 4	40 8 38.49	+0.49	15.0	.013	2
5391	3413	5.8	30 7	0 25.42	−0.53	15.1	−.015	12
5441	3454	8.7	33 55	2 44.01	−0.84	15.5	−.024	4
5537	3536	8.8	41 30	39 51 49.78	−0.02	14.1	−.001	2
5538	3537	7.8	41 31	40 5 31.04	−0.21	14.8	−.007	5
5539	3540	8.0	41 41	39 51 50.62	−0.98	15.7	−.030	4
5570	3563	7.0	43 55	40 4 28.17	−0.03	15.0	−.001	4
5631	3598	8.0	48 22	40 1 1.20	−0.09	15.2	−.002	5
5648	3609	8.3	50 18	39 56 36.69	−0.89	14.8	−.027	3
5738	3670	8.7	57 18	40 2 50.37	−0.22	15.5	−.006	3
5797		7.3	7 2 31	44 13.73	−1.27	15.7	−.104	5
5807		8.0	3 35	8 13.83	−2.11	16.0	−.054	3
5853		8.3	8 13	12 51.78	−0.42	15.1	−.010	6
5892		7.8	11 37	8 42.88	−1.52	15.2	−.049	7
5913		8.3	13 23	11 31.77	−1.43	16.0	−.034	2
6012	3869	8.8	21 30	39 57 42.70	+0.46	15.1	+.012	2
6044	3891	8.7	24 19	40 6 22.64	−2.31	15.5	−.060	4
6074	3910	8.2	26 10	39 59 16.22	−0.33	15.0	−.009	9
6086	3923	8.2	28 31	40 2 49.28	−0.72	15.0	−.018	6
6127	3937	8.4	31 49	40 1 55.99	−0.94	15.9	−.023	7
6192	3970	7.4	37 13	39 50 13.28	−0.82	15.6	−.023	3
6238	3995	6.9	41 44	40 1 54.01	−1.71	14.9	−.041	7
6255	4008	7.4	44 13	39 51 21.01	−0.51	16.1	−.011	3
6261	4012	8.7	44 50	40 0 1.01	+0.41	15.0	+.010	6
6284	4023	7.8	46 31	2 15.63	−1.67	15.6	−.015	4
6339		7.5	52 29	11 58.21	+0.04	15.2	+.001	5
6348		8.9	53 9	12 5.10	−0.60	15.0	−.015	2
6379	4086	6.9	56 16	5 25.74	−0.46	15.1	−.012	7

Bonn	Lund	Mag.	R. A. 1875.0	Dec. 1875.0	Diff.	Ep.	μ'	n
			h m s	° ' "	"		"	
6405		8.1	7 59 15	40 11 56.52	+0.02	15.5	+.000	4
6451	1141	7.4	8 4 33	39 50 38.84	−0.16	15.4	−.004	6
6509		8.1	10 26	40 6 47.23	−1.37	15.2	−.123	5
6515	1186	7.4	11 10	39 59 0.10	−1.10	15.3	−.003	4
6520		7.0	11 35	40 16 24.71	−0.26	15.0	−.007	2
6537	1205	8.4	13 14	40 4 39.29	−0.06	15.0	−.002	4
6558	1211	8.6	15 19	39 59 57.32	−0.98	15.4	−.027	3
6593		7.4	18 29	40 17 53.93	+0.83	14.6	+.021	1
6606		8.7	19 28	15 50.27	+0.67	16.0	+.015	2
6679		7.2	28 26	12 2.65	−0.65	15.9	−.016	8
6696	1299	7.9	29 43	4 39.98	−1.27	15.4	−.033	5
6755		8.2	36 15	18 40.04	−0.53	15.3	−.014	3
6789	1366	7.8	39 52	3 44.79	−0.66	14.9	−.018	6
6802	1373	8.4	41 51	3 3.68	−0.17	14.6	−.012	6
6889		6.6	53 37	12 8.58	−3.02	15.1	−.078	9
6972		7.6	9 2 51	17 42.79	−1.31	14.9	−.031	5
7007		8.3	6 15	13 21.57	−1.22	14.8	−.027	3
7057	1570	8.3	12 10	4 5.09	+0.39	14.9	+.016	5
7081		8.2	15 7	14 6.33	−0.27	15.5	−.007	3
7102		8.0	17 43	13 39.01	−2.09	14.8	−.040	6
7182		4.5	27 16	10 31.00	+0.80	15.0	+.019	8
7211		8.5	30 26	6 57.60	−3.44	14.9	.076	5
7241		5.5	31 15	19 32.91	−1.79	15.5	.043	5
7321		7.6	42 33	12 45.05	−0.05	14.9	.004	6
7333		7.7	44 6	12 22.15	−0.87	15.2	.020	6
7447		7.0	58 24	11 18.73	−0.77	15.0	.019	6
7458		7.3	59 0	6 40.20	−0.50	14.9	.012	7
7484		8.4	10 2 56	6 35.48	−1.52	14.6	.034	4
7488	4842	8.2	3 20	39 59 6.22	−1.13	14.8	−.028	3
7557	4879	8.6	14 21	56 9.64	−0.91	14.5	−.023	5
7627	4917	8.0	20 14	58 7.90	−1.30	14.5	−.036	7
7659		8.6	25 44	40 14 43.54	−1.16	15.1	−.026	6
7708	4990	7.8	32 36	3 16.64	−0.16	15.2	−.004	5
7754		8.3	38 56	9 6.21	+0.31	14.6	+.007	6
7764		6.9	40 51	24 6.09	−0.41	15.8	−.010	2
7829		8.3	49 51	24 22.46	+0.46	14.6	+.010	5
8050	5217	7.6	11 24 51	39 59 44.70	+0.66	14.5	+.019	4
8057	5216	5.7	22 20	40 1 29.75	+0.70	14.7	+.021	3
8096	5229	7.9	26 21	0 41.92	+0.17	14.6	+.005	6
8161		8.6	35 37	21 14.86	−2.50	14.7	−.056	2
8181		7.8	39 24	5 22.77	−0.65	14.8	−.016	6
8187		8.5	39 36	5 45.20	−0.50	14.6	−.012	6
8218		8.0	47 28	18 19.79	−0.61	14.8	−.013	7
8309		8.0	55 16	17 3.18	−2.32	15.1	−.051	7
8356		6.8	12 1 18	21 5.39	+0.29	14.9	+.006	6
8371		7.9	3 34	7 45.68	+0.38	15.2	+.008	7
8407	5383	6.9	8 20	2 16.49	−0.01	14.9	.000	6
8422		6.4	10 27	17 14.42	+1.62	15.0	+.036	3
8426		8.7	10 35	15 8.96	−1.34	14.8	−.030	2

Bonn	Lund	Mag.	R. A. 1875.0	Dec. 1875.0	Diff.	Ep.	μ′	n	Bonn	Lund	Mag.	R. A. 1875.0	Dec. 1875.0	Diff.	Ep.	μ′	n
			h m s	° ′ ″	″		″					h m s	° ′ ″	″		″	
8448		8.0	12 13 12	40 19 5.93	−0.47	15.2	−.010	6	10120	6509	7.6	15 39 32	39 58 7.06	+0.26	15.4	+.006	4
8461		8.9	14 57	12 15.35	1.47	14.2	−.033	2	10171	6539	8.4	44 52	40 3 20.78	−0.22	15.0	−.006	5
8531	5445	7.4	24 6	39 56 26.94	1.16	14.7	−.105	5	10188		7.4	47 7	6 44.71	+0.14	15.2	+.003	4
8537		6.6	24 57	40 16 22.43	+0.33	15.7	+.007	3	10246		8.0	50 44	8 57.20	+0.50	15.4	+.010	7
8550		9.1	26 31	12 36.88	0.32	14.8	−.007	2	10227	6572	6.0	53 0	3 45.28	+2.28	15.2	+.057	4
8572		7.0	29 13	22 23.07	0.73	14.9	.016	7	102[illegible]4		8.5	55 27	10 30.77	−0.53	15.4	−.012	4
8601	5497	7.3	32 [illegible]	39 59 59.05	5.27	15.0	.134	6	10323		8.7	16 1 52	4 53.13	−0.67	15.0	.017	5
8652	5531	[illegible]	[illegible] 1	39 57 36.24	5.39	15.2	.151	5	10393		8.2	7 44	7 22.38	+0.38	14.8	+.010	5
[illegible]		7	[illegible]	40 6 6.57	0.67	14.7	.015	5	10409		7.0	9 8	8 30.80	1.20	15.5	−.030	3
[illegible]	[illegible]	[illegible]	48 53	39 59 39.90	0.67	14.8	.016	7	[illegible]	6684	8.6	12 [illegible]	2 58.14	+0.64	15.1	.017	4
[illegible]		[illegible]	13 0 1	40 16 21.87	+2.37	15.0	.053	5	[illegible]	6744	5.0	15 38	0 32.27	+1.27	15.0	+.014	5
[illegible]		8.1	3 37	22 21.52	0.58	14.6	.013	3	[illegible]		8.3	22 [illegible]	10 6.40	1.40	15.4	−.032	4
[illegible]		[illegible]	17 38	17 29.40	0.30	15.7	.007	3	10551	6766	8.2	24 17	3 9.98	+0.08	15.3	+.002	5
[illegible]		7.2	17 49	4 56.84	1.11	15.5	.025	2	10647	6826	7.0	33 50	39 49 11.65	2.45	15.1	−.067	3
[illegible]		[illegible]	25 1	3 31.47	0.43	14.5	.010	1	10818	[illegible]	8.0	51 12	40 3 21.05	−1.20	14.9	.031	7
[illegible]		[illegible]	33 28	13 31.57	0.57	14.8	.012	2	10844	6955	8.6	53 30	39 54 31.07	+0.27	15.5	+.007	3
[illegible]		[illegible]	35 18	10 14.51	−0.89	15.4	.020	1	10858	[illegible]	8.3	54 12	54 13.47	−4.43	15.7	−.119	4
[illegible]		8.7	39 1	16 1.24	[illegible]	15.3	.067	3	10901	[illegible]	7.9	57 12	53 52.10	0.94	15.5	.025	7
[illegible]	[illegible]	[illegible]	[illegible]	9 51.97	0.32	14.7	.012	1	10911		[illegible]	58 13	40 15 11.45	−2.17	15.5	.055	3
[illegible]		[illegible]	[illegible] 27	17 18.30	1.20	15.1	.028	7	10945		8.4	17 2 44	5 51.48	1.12	15.1	.032	5
[illegible]	[illegible]	7	[illegible] 35	1 35.01	0.00	14.7	.002	5	[illegible]	7031	9.0	4 46	3 21.80	−0.72	15.5	−.016	2
[illegible]		[illegible]	[illegible] 17	7 8.22	[illegible]	[illegible]	.072	4	[illegible]	[illegible]	[illegible]	6 24	0 22.52	+1.32	15.0	+.033	5
[illegible]		7	5 [illegible]	7 1.92	2.38	[illegible]	.052	6	11066	7072	7.5	13 4	6 12.84	+1.04	15.0	+.029	7
[illegible]	[illegible]	[illegible]	5 26	1 1.72	0.77	15.1	.019	3	11100	7089	8.4	15 38	39 55 11.35	+1.26	15.4	+.032	4
[illegible]		7.1	10 28	15 30.70	−0.10	15.2	.002	7	11128		8.0	17 30	40 12 49.34	−0.09	15.5	−.002	3
[illegible]		6.0	14 19	19 30.93	+0.03	15.4	+.001	4	11129	7106	5.4	17 38	40 5 52.37	−1.98	15.5	−.051	3
[illegible]		8.7	16 34	8 29.87	+5.59	14.9	+.123	7	11151	7115	8.4	19 50	39 51 31.37	+0.87	15.8	+.023	3
9458		7.5	23 55	10 37.21	+0.21	14.9	.001	6	11244	7171	8.3	27 44	40 3 57.10	+0.24	15.2	+.006	5
[illegible]		8.2	26 13	14 59.28	+1.28	15.3	+.028	8		7233	8.3	36 1	39 49 3.03	+0.73	15.1	+.021	4
9576	[illegible]	7.7	37 18	39 56 25.82	+2.52	15.1	+.071	4	11396	7276	8.0	40 44	40 6 44.22	+0.57	15.2	+.014	5
9622	6232	7.8	44 44	39 59 1.83	+1.78	15.0	+.041	5	11434	7304	7.7	43 54	4 13.44	+4.74	15.3	+.118	4
9679		7.7	50 11	40 9 33.67	0.23	15.6	−.008	1	11483	7334	7.0	47 44	6 47.79	−0.16	15.1	−.004	4
9680	6261	8.7	50 53	39 58 50.86	−0.19	14.9	−.011	2	11495	7344	6.1	48 4	0 39.90	+1.80	15.3	+.045	5
9681		7.8	50 58	40 9 15.28	+0.28	15.6	+.008	1	11516	7368	5.2	49 44	1 59.55	+2.10	15.6	+.060	4
9721		6.5	54 38	8 33.90	+3.50	15.0	+.085	5	11643	7447	8.4	58 38	39 50 11.72	+0.47	15.3	+.014	4
9763		8.8	59 23	6 19.39	0.31	15.4	−.007	3	11673	7472	6.6	18 0 39	40 4 31.85	+0.65	15.1	+.016	5
9787	6316	8.4	15 2 14	5 27.93	+1.08	15.6	+.027	4	11727	7505	7.6	3 56	39 54 44.27	+2.37	15.3	+.064	6
9804		8.2	3 31	8 51.05	−1.45	15.4	−.032	4	11756	7526	7.8	5 48	54 31.86	+0.84	15.2	+.022	4
9810		8.6	7 36	7 47.13	−5.37	14.9	.132	6		7623	7.9	16 26	49 18.22	+0.02	15.1	+.001	7
9886	6376	8.1	13 59	3 58.38	−1.07	15.1	−.029	4	12009	7690	8.3	24 14	55 1.95	−0.20	15.3	−.006	4
9898		8.8	15 0	7 20.71	−1.09	15.4	−.029	4	12027	7703	8.1	25 28	50 37.66	−0.09	15.6	−.003	3
9926	6391	8.3	17 52	39 57 39.27	−1.58	15.0	.039	5		7735	8.2	27 22	48 11.02	−1.18	15.9	−.033	3
9929	6393	5.0	18 0	40 1 12.67	−0.08	15.4	−.002	4	12087	7753	7.1	29 10	40 3 49.98	+2.23	15.3	+.057	5
9984		7.3	25 32	20 14.96	−0.14	14.8	−.003	5	12181	7823	7.8	35 37	40 0 47.67	−2.73	15.3	−.073	5
9987		8.2	25 44	7 25.01	+0.31	15.4	+.008	3	12220	7842	8.8	37 18	39 52 21.33	−0.52	15.6	−.015	3
10005		7.3	27 10	6 8.92	+2.22	14.9	+.060	5		7849	8.0	38 32	39 46 52.13	−0.87	15.6	−.025	4
10050		7.3	31 30	11 40.11	+3.11	14.6	+.081	3	12289	7897	8.4	42 3	40 8 48.86	−0.59	15.6	−.015	4
10053		6.5	31 36	12 56.26	+2.56	15.5	+.068	5	12337	7924	8.3	44 47	39 55 10.07	−2.38	15.4	−.064	6
10113	6503	8.1	38 8	39 51 53.69	+0.81	15.1	+.023	3		7949	8.5	46 58	39 47 15.07	−1.53	15.7	−.044	3

Bonn	Lund	Mag.	R. A. 1875.0	Dec. 1875.0	Diff.	Ep.	μ'	n
			h m s	° ′ ″	″		″	
12433	8014	8.4	18 51 13	39 58 42.24	+0.34	15.5	+.009	3
12434	8016	7.0	51 18	40 0 59.04	+0.11	15.8	+.012	5
12440	8023	8.4	51 40	40 2 27.97	−0.23	16.0	−.006	3
	8067	7.9	56 25	39 40 9.38	−0.62	15.9	−.021	4
	8068	7.5	56 26	41 25.81	−0.79	15.6	−.023	4
	8087	7.5	58 56	46 14.78	+0.18	15.5	+.005	4
	8100	7.9	59 29	13 31.89	+0.20	15.6	+.006	4
12562	8105	7.8	59 53	55 51.19	−0.56	15.6	−.017	4
12582	8117	8.4	19 0 57	56 13.57	−1.28	15.5	−.036	4
	8189	7.0	6 46	10 3.27	−0.47	15.2	−.013	5
	8202	7.7	7 37	14 51.57	+1.17	15.9	+.034	3
	8203	8.3	7 39	18 15.14	−0.09	15.9	−.002	4
12737	8233	8.7	9 17	40 1 41.02	−0.58	15.7	−.016	3
12763	8253	7.9	11 1	39 53 12.59	−0.81	15.2	−.024	4
12844	8315	[illegible]	11 17	40 7 51.19	−0.81	15.1	−.023	5
12860	8325	7.1	15 27	40 2 9.77	−0.92	15.1	−.027	5
	8337	7.2	16 14	39 11 31.4	−1.17	15.4	−.034	4
12940	8396	8.2	20 38	40 4 11.97	−2.[illegible]	15.5	−.0[illegible]	3
12979	8417	8.4	22 19	39 53 7.12	+0.22	15.5	+.007	4
	8421	6.9	22 30	12 36.84	−1.0[illegible]	15.6	−.03[illegible]	5
	8451	6.4	24 21	11 3.8	−1.17	15.4	−.034	5
13059	8478	8.1	26 8	52 [illegible]5.59	−0.84	15.6	−.025	3
	8480	8.7	26 37	15 11.98	−0.82	15.9	−.022	3
	8537	8.1	30 52	15 0.67	−1.27	15.5	−.03[illegible]	2
	8543	7.1	31 24	15 8.02	−0.78	15.2	−.023	5
13201	8569	8.2	32 53	56 3.49	−1.86	15.0	−.053	4
	8630	6.8	37 22	13 15.17	−0.07	15.4	−.002	5
13287	8638	6.2	37 44	57 34.83	+1.03	15.7	+.028	4
	8646	7.8	38 16	13 51.83	−0.37	15.6	−.011	3
	8647	8.0	38 19	12 12.74	−1.46	15.6	−.042	4
	8659	7.2	38 47	12 0.14	+0.51	15.6	+.015	3
	8698	8.9	44 34	47 26.09	+0.49	15.5	+.014	4
13419	8736	8.5	44 47	56 54.01	−1.24	15.4	−.037	5
	8786	8.7	47 23	44 5.02	−0.48	15.5	−.022	4
	8812	6.8	51 20	50 31.15	−0.05	15.3	−.002	7
13551	8846	7.7	54 25	40 3 38.49	−0.21	15.0	−.006	4
13578	8873	5.7	52 53	1 58.42	+0.82	15.5	+.023	4
13661	8942	8.9	57 0	0 34.91	−0.64	15.5	−.019	4
13664	8943	7.6	57 6	39 57 9.65	−1.00	15.3	−.026	6
13678	8951	8.5	57 36	56 15.24	−0.11	15.7	−.003	5
	8964	7.4	58 39	49 23.36	−0.84	15.1	−.024	6
13704	8973	8.1	59 2	55 43.38	+0.13	15.7	+.003	4
	8999	8.7	20 0 52	50 44.21	−1.19	15.4	−.035	4
	9015	8.4	1 36	42 25.52	−0.38	15.4	−.011	5
	9025	9.0	2 15	52 30.45	−0.85	15.7	−.024	3
13797	9057	8.4	3 51	40 0 17.29	−0.51	15.6	−.013	3
	9070	8.3	4 34	39 49 57.29	−1.11	15.6	−.032	4
13858	9099	8.6	6 29	54 40.68	−0.87	15.6	−.026	3
13879	9113	6.9	7 22	57 25.26	+0.26	15.3	+.008	6
	9121	7.3	8 7	53 36.15	−0.05	15.3	−.001	6
13931	9162	7.4	20 10 0	39 56 58.66	+0.01	15.4	+.000	4
13934	9165	8.8	10 7	40 0 10.78	−1.37	15.7	−.041	2
	9173	8.4	10 16	39 42 52.62	+2.02	15.5	+.058	3
13995	9206	5.4	12 29	58 14.79	−0.01	15.6	.000	4
	9234	8.5	13 45	43 59.25	−0.45	15.5	−.013	3
14031	9239	8.4	13 56	59 54.26	−0.89	15.6	−.028	3
	9245	7.4	14 12	56 12.08	−0.72	15.5	−.021	5
14101	9298	8.2	17 8	40 2 57.58	−0.37	15.3	−.010	5
14114	9310	8.4	17 39	40 3 13.75	+1.15	15.3	+.033	3
	9314	[illegible]	17 47	39 51 26.75	−0.17	15.[illegible]	−.00[illegible]	5
14163	9319	[illegible]	19 34	55 9.05	−0.30	15.7	−.00[illegible]	4
	9358	[illegible]	20 18	44 52.52	−0.38	15.5	−.011	6
	[illegible]	8.2	20 53	44 24.19	−0.31	15.7	−.009	3
14201	[illegible]	6.6	21 34	59 34.54	−0.06	15.7	−.002	4
14215	[illegible]	7.8	22 13	56 12.65	0.05	15.9	+.001	3
	[illegible]	8.4	22 37	38 25.19	2.61	15.5	−.075	3
	9428	8.3	24 52	10 55.18	−1.12	15.2	−.033	4
14311	9454	7.3	[illegible] 26	40 5 11.10	−0.1[illegible]	15.[illegible]	.003	3
1432[illegible]	9457	7.2	26 31	40 0 20.12	0.15	15.[illegible]	−.00[illegible]	3
	9488	8.7	28 37	39 52 10.6[illegible]	−0.29	15.7	−.009	4
14451	9532	8.2	32 2	40 2 12.84	−0.26	15.3	−.007	5
14492	9562	8.2	34 [illegible]	39 59 14.27	0.55	15.7	.014	2
	9578	8.8	35 14	36 20.28	0.38	15.[illegible]	.013	3
	9589	8.4	36 27	52 22.19	1.51	15.0	.044	5
	9610	9.2	37 25	47 54.88	0.18	15.7	.013	3
14596	9628	8.0	39 1	56 37.23	1.55	15.7	.044	6
14603	9632	8.0	39 47	40 1 39.77	−2.13	15.0	−.051	3
14623	9644	8.7	40 21	39 57 28.82	0.03	15.2	−.001	4
	9670	8.8	43 23	52 19.07	0.27	15.[illegible]	.007	5
	9695	7.7	45 17	34 41.47	−0.27	15.5	.008	5
	9732	8.8	48 33	51 23.06	−2.20	15.5	−.062	4
	9751	7.4	50 44	49 22.76	−0.54	15.4	−.020	7
	9787	8.4	53 4	38 4.5	0.00	15.4	.000	5
	9789	8.2	53 43	47 24.77	−0.63	15.4	−.023	4
14924	9800	8.2	54 4	40 1 14.92	+0.83	15.7	+.023	4
	9807	8.3	54 27	39 34 27.67	−0.53	15.9	−.015	4
	9812	6.9	55 9	46 1.20	+5.30	15.3	+.218	5
	9817	8.2	55 44	50 38.56	+0.16	15.4	+.005	5
	9833	8.5	56 53	48 0.05	−0.05	15.3	−.002	3
	9837	7.8	57 10	49 10.84	−0.09	15.7	−.003	5
	9849	8.7	58 25	54 8.33	+0.03	15.4	+.001	4
	9853	8.4	58 32	45 7.19	−0.31	15.2	−.009	6
	9876	8.6	21 0 15	50 50.29	+0.39	15.7	+.013	4
	9901	7.9	2 4	49 1.35	−0.15	15.4	−.005	7
15103	9918	9.4	3 22	56 22.64	−0.61	15.7	−.017	2
	9934	8.0	4 45	39 12.02	−1.18	15.3	−.033	6
	9944	8.9	5 3	42 21.31	−0.66	15.7	−.019	3
15167	9962	8.6	6 24	54 55.40	+0.55	16.0	+.015	3
	9971	7.5	7 23	38 46.56	−1.04	15.3	−.033	5
15212	9993	8.8	8 31	56 33.24	−1.06	15.3	−.034	4

Bonn	*Lund*	Mag.	R. A. 1875.0	Dec. 1875.0	Diff.	Ep.	μ'	n
			h m s	° ′ ″	″		″	
	9999	8.9	21 9 6	39 39 18.80	−0.50	15.5	−.014	5
	10026	9.0	12 8	18 35.77	+0.07	15.6	+.002	3
	10040	8.6	13 16	51 53.89	−0.26	15.5	−.007	1
	10042	8.9	13 29	13 21.01	+0.71	15.7	+.023	2
15345	10056	8.6	14 35	56 17.41	+0.76	15.4	+.022	4
	10074	8.7	15 51	44 0.80	−0.30	15.3	−.010	5
	10076	6.6	16 9	49 11.73	−7.07	15.0	−.201	5
15501	10142	8.6	21 56	40 2 0.21	+0.21	15.5	+.007	2
	10159	7.5	24 0	39 50 16.82	−0.28	16.0	−.008	3
15563	[illegible]	8.2	24 2	55 23.25	−0.90	15.4	−.029	1
	[illegible]	7.6	24 7	45 28.36	+1.18	15.7	+.044	1
	[illegible]	9.2	25 26	39 40.09	0.01	15.5	−.000	2
	10192	8.6	27 53	40 31.19	+0.20	15.4	+.007	5
	10193	7.0	27 57	54 46.73	−0.87	15.5	−.024	2
	10194	9.1	27 58	51 58.32	−0.68	15.6	−.019	2
	10197	9.1	28 23	51 52.81	+0.31	15.7	+.009	3
	10207	8.7	29 12	53 17.06	−0.24	15.6	−.008	3
	10208	8.7	29 14	44 19.87	−0.52	15.7	−.015	2
	10220	8.3	29 32	38 17.89	−0.21	15.6	−.006	2
	10221	7.9	30 39	31 34.57	−0.97	15.7	−.031	3
	10225	8.2	30 57	38 51.11	−1.06	16.1	−.012	2
	10238	5.4	31 56	51 10.64	+1.54	15.9	+.038	6
	10253	8.4	34 15	46 51.08	−0.28	15.2	−.008	8
15860	10276	7.8	36 46	57 23.94	−0.90	15.2	−.026	6
	10296	8.8	38 8	51 31.06	−0.04	15.2	−.001	5
	10309	9.0	40 5	51 6.55	+0.47	15.7	+.016	3
	10312	8.5	40 26	51 0.22	+0.68	15.6	+.019	3
	10314	8.9	40 43	51 19.06	+0.10	15.7	+.005	3
	10377	9.1	47 14	48 56.82	−0.58	15.4	−.016	4
	10389	8.9	48 38	49 58.32	−3.78	15.7	−.108	5
	10430	8.8	53 39	36 2.00	−1.30	15.6	−.044	4
	10530	8.4	22 5 20	38 51.92	+0.92	15.1	+.026	1
	10538	7.7	5 57	33 11.26	+0.06	15.7	+.002	4
16463	10552	8.1	7 12	56 51.79	−0.65	15.4	−.018	4
	10565	8.9	8 39	52 38.91	+0.94	15.6	+.027	3
	10568	7.7	8 56	51 53.81	−0.09	15.3	−.003	6
	10611	8.5	15 2	44 18.82	+0.32	15.3	+.013	6
	10638	6.0	17 37	44 7.95	−0.25	15.7	−.007	3
16666	10640	8.2	18 8	56 51.31	−1.06	15.5	−.032	3
	10658	8.0	21 21	55 20.32	−1.08	15.4	−.030	4
	10690	8.8	23 33	40 36.77	+0.57	15.7	+.016	5
	10701	7.9	25 0	33 37.74	+0.54	15.4	+.021	4
	10716	8.5	26 14	38 34.01	−0.26	15.5	−.007	5
	10716	8.5	26 14	38 34.01	0.26	15.5	.007	5
16843	10723	7.4	26 52	58 22.75	1.50	15.6	.040	4
	10770	8.9	30 50	44 14.22	0.08	15.4	−.003	4
	10783	9.0	31 52	31 13.86	0.01	15.7	−.001	3
16965	10803	7.4	33 49	56 59.34	1.09	15.3	.032	3
	10831	5.7	35 53	34 22.19	+0.19	15.3	+.009	5
	10855	8.5	37 19	32 29.86	+0.26	15.5	+.009	3
	10875	8.4	22 40 30	39 40 1.53	−1.17	15.7	−.033	5
	10903	9.0	43 48	50 55.14	−0.69	15.5	−.026	4
	10928	7.8	46 39	36 7.80	−0.10	15.2	−.011	6
	10939	8.0	47 12	40 14.98	−0.32	15.4	−.009	4
	10944	8.4	47 50	36 12.97	−0.73	15.7	−.025	6
	10950	5.8	48 23	42 40.18	+0.88	15.0	+.033	3
	11046	8.8	23 0 44	55 46.15	−1.45	15.7	−.039	3
	11062	8.6	2 30	38 37.39	−2.31	15.7	−.066	4
	11068	8.4	3 43	30 23.59	+0.69	15.6	+.023	4
	11085	8.6	5 50	50 39.39	−0.44	15.4	−.014	5
	11100	8.2	7 50	54 51.64	+0.94	15.7	+.026	5
	11106	8.5	9 9	44 25.55	−1.25	15.7	−.035	3
	11114	8.9	10 50	42 42.19	+0.19	15.6	+.007	3
17620	11120	8.6	11 20	58 45.98	+0.33	15.8	+.008	3
	11131	8.2	12 54	45 16.12	−0.88	15.4	−.025	5
	11143	8.6	14 6	37 22.08	−0.52	15.7	−.018	2
	11160	9.0	16 30	48 44.72	−0.98	15.2	−.034	4
	11166	7.9	17 35	32 53.31	−0.29	15.7	−.008	5
	11183	9.4	19 48	47 44.48	−1.32	15.6	−.038	4
	11188	6.9	20 26	42 44.53	−5.57	15.7	−.159	4
	11221	8.4	25 20	34 20.97	−0.23	15.6	−.007	4
	11233	6.0	28 31	32 18.36	−1.74	15.7	−.054	3
	11243	8.9	29 22	49 52.61	−0.59	15.8	−.020	3
	11261	8.4	32 2	49 15.43	−0.57	15.2	−.016	4
	11262	8.0	32 15	47 14.93	−0.47	15.7	−.016	3
	11288	7.4	35 49	54 47.85	−2.55	15.4	−.088	3
	11294	8.4	35 39	37 19.82	+0.82	15.7	+.023	3
	11304	9.0	37 37	36 52.22	−1.48	15.7	−.041	3
	11314	8.4	39 20	44 55.80	+1.50	15.4	+.043	5
	11370	8.4	48 2	37 10.44	+0.21	15.4	+.006	6
	11426	8.4	56 32	42 59.73	−1.07	15.7	−.030	6
	11448	6.7	59 38	43 21.01	−0.69	15.7	−.019	4

NOTES

Bonn

1418 =	Boss 369	7321	Boss 2633
1336	Boss 1259	8057	Boss 3023
1877	Doo. 3	8531	Cr. 1581
5139	Doo. 6	8651	Boss 3324
5211	Doo. 9	9178	Doo. 50
5391	{ Doo. 12 / Boss 1688	9350	Cr. 1875
5570	Doo. 15	9929	{ Doo. 62 / Boss 3922
5797	Cr. 862	10050	Cr. 2086
6238	Doo. 30	10053	Cr. 2087
6284	Doo. 31	10466	Boss 4161
6379	Doo. 32	10818	Doo. 65
7182	Boss 2570	10991	Doo. 68
7241	Boss 2601	11129	Boss 4144

Bonn

11434	Doo. 77; Ci. 2369	12562	Doo. 90
11495	Boss 4518	12763	Doo. 94
11516	Boss 4522; Doo. 78	12841	Boss 4930
11727	Doo. 81	13287	Boss 5035
12009	Doo. 84	13578	Boss 5113
12181	Doo. 85	13995	Boss 5205
		16965	Doo. 120

Lund

1339	= Boss 610	10159	Doo. 102
2127	Ci. 555	10193	Doo. 103
3290	Doo. 10	10238	Doo. 104; Boss 5553
9311	Boss 5229	10568	Doo. 113
9751	Doo. 98	10831	Boss 5856
9812	Ci. 2718	10950	Ci. 2994
9837	Doo. 99	11233	Boss 6063
9901	Doo. 100		
10076	Doo. 101; Ci. 2773		

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SOLAR MOTION FROM RADIAL VELOCITIES.

By J. S. PARASKEVOPOULOS.

A homogeneous list of the radial velocities of 537 stars, given in the *Publications of the Dominion Observatory of Victoria B. C.* (Vol. II, No. 1, 1921) offers a good opportunity for attempting to derive the elements of the solar motion. These stars, taken from Boss' *Preliminary Catalogue* between the 5th and 8th mags., all belong to the northern part of the sky and therefore a solution based upon these stars alone would be subject to well known objections. However, Voûte in his *First Catalogue of Radial Velocities* offers a good number of southern stars which, in combination with the above mentioned 537 northern stars, sufficiently cover the entire sky.

I have made three solutions for deriving the amount and the direction of the solar motion.

First. A solution containing the northern stars only.

Second. A solution containing the southern stars only.

Third. A solution containing both, the northern and the southern stars.

From the radial velocities of the southern stars of Voûte's Catalogue I omitted those of the nebulæ, clusters, and of the center of gravity of the spectroscopic binaries.

Grouping of the stars. The total number of the stars used for the present solution is:

*	Radial velocities Positive	Negative	Total
Northern	201	336	537
Southern	551	192	743
Total	752	528	1280

These stars have been divided into groups, each group covering an average area of 30^m square (roughly $8° \times 8°$). The number of the groups are for the northern stars 163; for the southern stars 216. A preliminary survey of the positive and negative velocities shows immediately that the positives predominate in the hemisphere from 0^h to 12^h of right ascension and the negatives in the hemisphere from 12^h to 24^h.

High velocity stars. 84% of the total number of stars used, have radial velocities not exceeding 30 kil/sec. The radial velocities of the remaining 16% are distributed as follows.

Stars Kil/sec	30–40	40–50	50–60	60–70	70–80	80–90	90–100	100–over
Northern.....	48	33	12	6	2	0	1	0
Southern.....	52	22	10	8	4	3	4	8

A plot of these 213 high velocity stars shows clearly the prevalence of the +'s in the hemisphere from 0 to 12 hours of right ascension and of the −'s in the hemisphere from 12 to 24, without any particular condensation in any limited area of the sky.

Results. I have assigned equal weights to all the velocities involved in the solutions. The results are as follows:

For 1900.0

	Northern Stars	Southern Stars	Northern and Southern Stars	
	°	°	°	°
α	271.1	272.2	271.6	±3.0
δ	+ 31.6	+ 29.6	+ 30.3	±3.0
V	−20.7 km/s	− 25.1	− 23.33	±1.03

Let us consider the normal equations involved in the solution containing all the stars, northern and southern. The condition

$$\Sigma xy = \Sigma xz = \Sigma yz = 0$$

where:

$x = \rho \sin \delta$, $y = \rho \cos \delta \cos \alpha$ and $z = \rho \cos \delta \sin \alpha$

should be met if the stars are evenly distributed over the whole sky. In the present solution this condition is very nearly satisfied as shown by the following normal equations:

$$
\begin{array}{rrrrrr}
+151.773\,A & + & 1.252\,B & - & 0.929\,C & = -1803.217 \\
 & & +110.528 & - & 0.191 & = -81.893 \\
 & & & & +116.417 & = +2355.737
\end{array}
$$

Proceeding according to EJNAR HERTZSPRUNG's method, given in the *Bulletin of the Astronomical Institute of the Netherlands* No. 16 (p. 84), we could entirely satisfy the condition $\Sigma xy = \Sigma xz = \Sigma yz = 0$ by omitting the necessary number of stars. However, if we compare the results from the separate solutions for the northern and for the southern stars, as given above, we see that the improvement in the final values of the elements of the solar motion could not exceed the amount of the probable errors.

National Observatory, Athens, Greece,
October, 1922.

OBSERVATIONS OF THE COMET *BAADE*,

MADE WITH THE $18\frac{1}{2}$-INCH EQUATORIAL OF THE DEARBORN OBSERVATORY.

By LLOYD R. WYLIE.

Date	G.M.T.	Star	Comp.	☌ − ★ Δα	☌ − ★ Δδ	App. α	App. δ	Log pΔ α	Log pΔ δ
	h m s			m s	′ ″	h m s	° ′ ″		
Oct. 24	5 0 10	1	12 1	+0 9.12	−1 37.0	19 58 3.09	36 18 20.7	9.6250	0.3564
25	13 15 49	2	8 2	−3 27.52	+1 37.3	20 0 9.24	36 2 26.0	9.3539	0.0951
25	17 30 40	3	16 6	−1 41.84	+2 41.7	20 0 33.46	35 59 12.9	9.7316	0.6679
26	13 11 7	4	12 5	−1 1.67	−0 53.8	20 2 25.71	35 45 18.2	9.3409	0.1031
27	13 28 8	5	20 5	+0 44.81	−2 31.9	20 4 14.25	35 27 31.3	9.4111	0.1613

Mean Places of the Comparison Stars for 1922.0 and Reduction to Apparent Place

No.	α	Red. α	δ	Red. δ	Authority
1	19 57 52.86	+1.84	36 22 25.1	+32.6	*A. G. Lund* 8930
2	20 3 34.90	1.86	36 0 16.0	32.7	*A. G. Lund* 9019
3	20 2 13.45	1.85	36 55 58.5	32.7	*A. G. Lund* 8991
4	20 3 28.53	1.85	35 45 39.4	32.6	*A. G. Lund* 9016
5	20 1 27.61	1.83	35 29 30.7	32.5	*A. G. Lund* 9036

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THE PROPER-MOTIONS OF 315 RED STARS.

By RALPH E. WILSON

Soon after the publication of the *Proper-Motions of 154 Red Stars*[1], the writer received observations of a large number of these stars by GYLLENBERG[2] at Lund in the years 1917–1920. Additional observations of the southern stars, also, became available with the distribution of the Cordoba Zone Catalog B, and a complete re-examination of the data, including some of the older catalogs which in the first investigation were considered of too small weight, has been made. As a result of this survey, the proper-motions of 315 stars have been derived. The systematic errors of the catalogs have been eliminated as far as possible by reduction to the system and weights of the *Preliminary General Catalog*. All proper-motions with probable errors equal to or less than ″.015 in either coordinate are included in Table I and were given weight 1.0 in the solutions. Those with probable errors between ″.015 and ″.025 may be considered fair approximations and they have been given weight 0.5 in the solutions. The remainder are quite uncertain but they are the results from the material at present available. They are listed with those of weight 0.5 in Table II, being given only to the second decimal place, and are assigned a weight 0.2. Exceptions to this system have been made in the cases of a few stars as noted below the tables. In six cases, no meridian observations being available, the proper-motions derived from photographs by the MISSES YOUNG and FARNSWORTH[3] have been used. In three cases, meridian proper-motions of weight 0.5 have been combined with the photographic and assigned a weight 1.0. Except where noted, the proper-motions have been determined by the writer. In Table I are listed the star, position for 1900, Harvard classification of spectrum, proper-motion in right-ascension in time and arc with the probable error, proper-motion in declination with probable error and the total proper-motion. In Table II are given the star, its position, classification of spectrum and the three proper-motions, the weight used in the solutions being indicated by the presence or absence of the colon.

[1] *Astronomical Journal*, *34*, 23, 1922.

[2] *Meddelanden fran Lunds Astronomiska Observatorium*, Series II, No. 27, 1922.

[3] *Astronomical Journal*, *33*, 191, 1921.

TABLE I

	★	α	δ	Sp.	μ_α	μ_α	p. e.	μ_δ	p. e.	μ
		h m	° ′		s	″	″	″	″	″
1	*H. D.* 151 . . .	0 1.2	−33 22	Md	−.0003	−.004	±.007	+.018	±.008	.018
2	*S Sculptor*.	10.3	−32 36	Md	+ 65	+.082	11	+.041	12	.092
3	*ST Cassiopeia*	12.2	+49 44	Nb	+ 30	+.029	10	+.022	15	.036
4	*VX Andromeda* . .	14.6	+44 9	Pec.	− 09	−.010	05	−.002	07	.010
5	*T Cassiopeiæ*	17.8	+55 14	Md	+ 46	+.040	05	−.001	08	.040
6	*R Andromedæ*	18.8	+38 1	R?	− 11	−.013	06	−.022	07	.026
7	*H. D.* 2342	22.2	+35 2	Nb	− 01	−.001	06	−.014	07	.014
8	*Z Piscium*	1 10.6	+25 14	Na	− 06	−.008	02	+.002	05	.008

	★	α	δ	Sp.	μ_α	μ_δ	p. e.	μ	p. e.	μ
		h m	° ′		s	″	″	″	″	″
9	*S Cassiopeiæ*	1 12.3	+72 5	Pec.	+.0017	+.008	±.004	−.034	±.011	.035
10	*R Sculptoris*	22.4	−33 4	Nb	− 22	−.028	09	−.037	10	.046
11	*R Piscium*	25.5	+ 2 22	Md	− 08	−.012	10	+.001	08	.012
12	*Y Andromedæ*	33.8	+38 50	Md	− 03	−.004	10	−.012	11	.013
13	*U Persei*	53.0	+54 20	Md	+ 33	+.029	06	+.006	14	.030
14	*V Arietis*	2 9.6	+11 17	Nb	+ 21	+.031	07	+.055	07	.063
15	*R Arietis*	10.4	+24 35	Md	+ 20	+.027	06	−.022	06	.035
16	*o Ceti*	14.3	− 3 26	Md	− 04	−.006	01	−.229	01	.229
17	*S Persei*	15.7	+58 8	Md	+ 11	+.009	06	+.011	10	.014
18	*R Ceti*	20.9	− 0 38	Md	+ 22	+.033	09	−.022	09	.040
19	*H. D.* 16115	30.2	− 9 53	R3	+ 02	+.003	09	+.006	08	.007
20	*UY Andromeda*	32.1	+38 14	N	− 33	−.039	11	+.020	13	.044
21	*Y Arietis*	35.0	+30 47	Me	− 40	−.043	09	+.015	10	.020
22	*T Arietis*	42.8	+17 6	Me	− 21	−.030	07	−.047	08	.034
23	*W Persei*	43.2	+56 34	Me	− 06	−.005	06	+.010	12	.011
24	*H. D.* 19557	3 3.7	+57 31	R5	− 01	−.001	05	−.001	09	.004
25	*H. D.* 19881	6.7	+47 27	Np	− 11	−.011	10	−.011	15	.016
26	*H. D.* 20234	10.0	−57 41	Na	+ 11	+.009	02	+.015	04	.018
27	*Y Persei*	20.9	+43 50	Nb	+ 29	+.031	09	−.002	12	.031
28	*U Camelopardalis*	33.2	+62 19	Nb	+ 14	+.010	04	+.017	09	.020
29	*T Eridani*	51.0	−24 20	Md	+ 20	+.027	15	+.000	15	.027
30	*H. D.* 25408	57.2	+61 32	R8	− 25	−.018	05	+.007	10	.019
31	*RV Camelopardalis*	4 22.4	+57 11	Md	− 59	−.048	08	−.032	14	.058
32	*R Tauri*	22.8	+ 9 56	Md	− 16	−.024	10	−.003	10	.024
33	+36° 911	27.3	+36 29		− 25	−.030	13	+.003	15	.030
34	*R Reticuli*	32.5	−63 14	Md	− 24	−.016	07	+.048	12	.051
35	+27° 677	32.7	+27 58		− 10	−.013	13	+.026	12	.029
36	*R Doradus*	35.6	−62 16	Me	− 146	−.081	04	−.085	07	.117
37	*ST Camelopardalis*	40.8	+67 59	Nb	− 02	−.001	01	−.003	04	.003
38	*H. D.* 30443	42.7	+34 49	Nb	+ 24	+.030	08	−.033	11	.045
39	*R Pictoris*	43.5	−49 26	Md	+ 51	+.049	11	+.019	15	.069
40	*TT Tauri*	45.2	+28 21	Nb	− 14	−.015	07	+.016	08	.022
41	*R Orionis*	53.6	+ 7 59	R?	+ 29	+.043	12	−.078	10	.089
42	*R Leporis*	55.0	−14 57	Pec.	− 07	−.010	07	+.010	07	.014
43	*H. D.* 32088	55.6	+50 29	Nb	+ 15	+.014	06	−.003	13	.014
44	*W Orionis*	5 0.2	+ 1 2	Nb	+ 04	+.002	04	−.005	04	.005
45	*TX Auriga*	2.2	+38 52	Nb	− 05	−.006	11	+.012	13	.013
46	*H. D.* 33404	4.9	− 5 38	Nb	+ 15	+.022	11	+.022	11	.034
47	*R Auriga*	9.2	+53 28	Md	+ 29	+.026	05	−.046	12	.053
48	*H. D.* 34467	12.5	+35 41	Nb	+ 13	+.016	09	−.007	10	.017
49	*UV Auriga*	15.3	+32 24	R?	+ 14	+.018	07	−.005	08	.019
50	*T Columba*	15.6	−33 49	Md	+ 25	+.034	10	+.036	12	.048
51	*S Auriga*	20.5	+34 1	Nb	+ 33	+.040	...	+.014	...	.042
52	*RT Orionis*	27.8	+ 7 4	Nb	− 22	−.033	11	+.012	10	.035
53	+22° 947	28.7	+22 6		+ 12	+.017	06	±.000	09	.017
54	*TU Tauri*	39.4	+24 23	Nb	+ 09	+.012	07	+.001	07	.012
55	*Y Tauri*	39.7	+20 39	Nb	+ 07	+.010	07	+.017	07	.020
56	*H. D.* 38572	44.7	+30 36	Na	+ 14	+.018	07	+.003	08	.018
57	*TW Auriga*	49.7	+45 29	Me	+ 07	+.007	14	−.022	15	.023
58	*S Leporis*	6 4.6	−24 11	Me	+ 06	+.008	07	−.016	06	.018

	★	α	δ	Sp.	μ_α	μ_δ	p. e.	μ	p. e.	μ
		h m	° ′		s	″	″	″	″	″
59	*TU Geminorum*	6 4.7	+26 3	Na	+.0005	+.007	±.003	−.007	03	.010
60	*H. D.* 44541	17.2	+ 3 29	Me	+ 17	+.026	14	−.041	12	.049
61	*H. D.* 44984	19.8	+14 18	Nb	+ 16	+.023	07	−.005	07	.024
62	*UU Aurigæ*	29.7	+38 31	Na	+ 19	+.022	03	−.022	04	.031
63	*H. D.* 47883	35.7	+31 33	Na	− 10	−.013	08	−.025	09	.028
64	*H. D.* 49217	42.4	+ 0 48	Pec.	+ 21	+.032	14	−.021	15	.038
65	*H. D.* 51208	51.3	−42 14	Na	+ 10	+.011	04	+.012	04	.016
66	*X Monocerotis*	52.4	− 8 56	Md	+ 01	+.001	13	+.009	12	.009
67	*R Lyncis*	53.0	+55 27	Pec.	− 12	−.010	08	−.075	13	.076
68	*RV Monocerotis*	53.0	+ 6 18	Nb	− 05	−.007	09	+.004	08	.007
69	*H. D.* 53132	56.1	− 3 6	R5	− 09	−.014	09	+.002	09	.014
70	*R Geminorum*	7 1.3	+22 52	R?	+ 06	+.008	05	+.002	05	.008
71	*RY Monocerotis*	2.1	− 7 24	. . .	+ 15	+.022	11	+.024	10	.033
72	*R Canis Minoris*	3.2	+10 11	Pec.	+ 04	+.001	05	−.006	04	.006
73	*W Can. Majoris*	3.4	−11 46	Na	+ 05	+.007	07	+.014	06	.016
74	*L₂ Puppis*	10.5	−44 28	Md	+ 108	+.116	04	+.328	04	.348
75	*H. D.* 58364	20.2	+22 5	R5	+ 13	+.018	15	+.005	15	.019
76	*H. D.* 58385	20.3	− 2 57	Nb	+ 04	+.006	14	−.043	11	.043
77	*H. D.* 58881	22.4	−11 31	Rp	+ 02	+.003	13	+.005	14	.006
78	*H. D.* 59643	25.8	+24 44	R8	− 03	−.004	06	−.010	06	.011
79	*S Canis Minoris*	27.3	+ 8 33	Md	+ 10	+.015	15	+.023	14	.027
80	*S Geminorum*	37.0	+23 41	Md	− 05	−.007	06	−.027	06	.028
81	*T Geminorum*	43.3	+23 59	R?	+ 05	+.007	05	−.001	05	.007
82	*W Canis Minoris*	43.4	+ 5 40	Na	+ 09	+.013	13	+.012	12	.018
83	*U Puppis*	56.1	−12 34	Md	− 11	−.016		−.036		.039
84	*R Cancri*	8 11.0	+12 2	Md	+ 05	+.007	05	−.007	05	.010
85	*RY Hydræ*	11.9	+ 3 5	Np	+ 01	+.002	09	+.009	08	.009
86	*V Cancri*	16.0	+17 36	Md	+ 03	+.004	08	−.006	09	.007
87	*RT Hydræ*	24.7	− 5 59	Me	+ 37	+.055	11	−.037	14	.066
88	*U Cancri*	30.1	+19 14	Md	+ 06	+.009	08	−.009	09	.013
89	*R Pyxidis*	41.3	−27 50	Md	− 39	−.052	13	−.006	14	.052
90	*H. D.* 75021	42.4	−29 21	R8	− 29	−.038	07	−.011	08	.040
91	*S Hydræ*	48.4	+ 3 27	Md	+ 16	+.024	07	+.016	04	.029
92	*X Cancri*	49.7	+17 37	Nb	+ 03	+.004	03	+.004	03	.006
93	*T Hydræ*	50.8	− 8 46	Md	− 08	−.012	06	−.004	06	.013
94	*T Cancri*	54.0	+20 14		− 09	−.013	05	−.008	04	.015
95	*H. D.* 76846	53.6	+34 9	Ro	+ 07	+.009	09	−.021	14	.023
96	*H. D.* 77234	56.2	+50 29	R5	− 04	−.004	06	−.002	10	.004
97	*RS Cancri*	9 4.6	+31 23	Me	− 09	−.012	04	−.051	05	.052
98	*H. D.* 79319	8.3	+14 37	R5	+ 02	+.003	08	−.012	07	.012
99	*R Carinæ*	29.7	−62 21	Md	− 74	−.052	04	+.012	06	.053
100	*R Leonis Minoris*	39.6	+34 58	Md	+ 10	+.012	07	−.014	09	.018
101	*R Leonis*	42.2	+11 54	Md	− 01	−.001	03	−.042	03	.042
102	*H. D.* 85349	45.9	− 1 33	Nb	+ 03	+.004	10	+.005	10	.006
103	*Y Hydræ*	46.4	−22 32	Np	− 15	−.021	08	−.006	08	.022
104	*X Velorum*	51.3	−41 7	Nb	− 21	−.024	09	−.030	10	.038
105	*V Leonis*	54.5	+21 44	Md	+ 07	+.010		−.019		.021
106	*S Carinæ*	10 6.2	−61 4	Md	− 129	−.093	04	+.062	07	.112
107	*H. D.* 88539	7.5	−34 50	Na	− 10	−.012	06	+.009	07	.015
108	*U Antliæ*	30.8	−39 3	Nb	− 42	−.049	05	−.004	05	.049

	★	α	δ	Sp.	μ_α	μ_α	p. e.	μ_δ	p. e.	μ
		h m	° ′		s	″	″	″	″	″
109	*U Hydræ*	10 32.6	−12 52	Nb	+.0022	+.032	±.005	−.020	±.004	.038
110	*R Ursæ Minoris*	37.6	+69 18	Md	− 96	−.051	03	−.022	07	.056
111	*H. D.* 92839	38.1	+67 56	Na	+ 16	+.009	02	−.010	07	.013
112	*V Hydræ*	46.8	−20 43		− 42	−.059	09	−.002	10	.059
113	*R Crateris*	55.6	−17 47	Me	− 14	−.020	09	+.004	09	.020
114	*H. D.* 100764	11 30.7	−11 2	Ro	+ 28	+.041	14	−.003	15	.041
115	*S Crateris*	47.6	− 7 3	Me	− 14	−.021	11	−.006	11	.022
116	*Z Ursæ Majoris*	51.3	+58 25	Md	− 19	−.015	07	−.018	12	.023
117	*T Virginis*	12 9.5	− 5 29	Md	− 03	−.004	12	+.003	11	.005
118	*H. D.* 107347	15.2	− 8 27	Me	− 08	−.012	14	−.028	14	.030
119	*SS Virginis*	20.1	+ 1 20	Np	+ 04	+.006	06	−.003	06	.007
120	*R Virginis*	33.4	+ 7 32	Md	− 29	−.043	09	−.009	09	.044
121	*Y Ursæ Majoris*	35.8	+56 24	Me	− 15	−.012	06	+.017	10	.021
122	*S Ursæ Majoris*	39.6	+61 38	Pec.	− 47	−.033	03	−.004	05	.033
123	*Y Can. Venaticorum*	40.4	+45 58	Nb	+ 08	+.008	02	+.005	03	.010
124	*U Virginis*	46.0	+ 6 6	Md	+ 04	+.006	06	+.001	06	.006
125	*RY Draconis*	52.5	+66 32	Np	+ 04	+.002	03	−.032	08	.032
126	*H. D.* 112869	54.7	+38 20	Na	− 03	−.004	07	−.019	08	.019
127	*RT Virginis*	57.6	+ 5 43	Md	+ 32	+.048	10	−.017	10	.051
128	*SW Virginis*	13 8.9	− 2 16	Me	− 37	−.056	07	−.012	07	.057
129	*V Virginis*	22.6	− 2 39	Md	+ 07	+.010	08	+.028	07	.030
130	*R Hydræ*	24.2	−22 46	Md	− 47	−.065	03	−.002	04	.065
131	*S Virginis*	27.8	− 6 41	Md	− 01	−.001	06	−.002	06	.002
132	*T Centauri*	36.0	−33 6	Md	− 23	−.029	06	−.001	07	.029
133	*W Hydræ*	43.4	−27 52	Md	− 41	−.055	07	−.065	07	.085
134	*R Centauri*	14 9.4	−59 27	Md	− 36	−.027	05	−.020	08	.034
135	*S Bootis*	19.5	+54 16	Md	+ 19	+.017	05	−.039	08	.043
136	*RX Bootis*	19.7	+26 11	Me	+ 17	+.023	06	−.046	06	.051
137	*Y Centauri*	25.1	−29 39	Me	− 30	−.039	11	−.032	11	.050
138	*V Bootis*	25.7	+39 18	Md	+ 26	+.030	08	−.042	10	.052
139	*R Bootis*	32.8	+27 10	Md	− 14	−.019	05	+.009	05	.021
140	*X Triang. A.*	15 4.7	−69 42	Nb	+ 08	+.004	02	−.011	04	.012
141	*S Serpentis*	17.0	+14 40	Md	+ 11	+.016	11	+.008	10	.018
142	*S Coronæ*	17.3	+31 41	Md	− 02	−.003	07	−.022	07	.022
143	*U Libræ*	36.2	−20 51		+ 24	+.034		−.044		.056
144	*T Normæ*	36.4	−54 40	Md	− 32	−.028	09	−.068	10	.074
145	*V Coronæ*	46.0	+39 52	Nb	+ 42	+.048	07	+.007	08	.049
146	*R Serpentis*	46.1	+15 26	Md	− 05	−.007	10	−.053	10	.053
147	*ST Herculis*	47.8	+48 48	Me	+ 22	+.022	10	−.001	14	.022
148	*X Herculis*	59.6	+47 31	Me	− 46	−.046	08	+.048	12	.066
149	*R Herculis*	16 1.7	+18 38	Md	+ 13	+.018	07	−.010	08	.021
150	*U Serpentis*	2.5	+10 12	Md	+ 02	+.002		+.049		.049
151	*V Ophiuchi*	21.2	−12 12	Nb	+ 03	+.004	12	−.010	13	.011
152	*RS Scorpii*	48.4	−44 56	Md	+ 35	+.037	10	−.034	13	.050
153	*RR Scorpii*	50.2	−30 25	Md	− 14	−.018	10	−.016	12	.024
154	*R Ophiuchi*	17 2.0	−15 58	Md	− 14	−.020	12	−.028	11	.034
155	*TW Ophiuchi*	23.8	−19 21	Nb	− 01	−.001	10	−.006	10	.006
156	*V Pavonis*	31.7	−57 10	Nb	± 00	±.000	06	−.059	10	.059
157	*SZ Sagitt.*	39.1	−18 37	Nb	+ 12	+.017	11	+.023	14	.029

	★	α	δ	Sp.	μ_α	μ_α	p. e.	μ_δ	p. e.	μ
		h m	° ′		s	″	″	″	″	″
158	*R Pavonis*	18 3.3	−63 38	Md	−.0004	−.003	±.008	+.018	±.015	.018
159	*T Herculis*	5.3	+31 0	Md	+ 04	+.005	06	+.009	06	.010
160	*RY Ophiuchi*	11.6	+ 3 40	Md	− 07	−.010	12	−.013	12	.016
161	*T Lyræ*	28.9	+36 55	. .	+ 11	+.013	14	+.021	11	.025
162	*RX Scuti*	31.7	− 7 41	Nb	+ 31	+.046	13	−.007	13	.047
163	*X Ophiuchi*	33.6	+ 8 44	Md	+ 09	+.013	13	+.023	12	.026
164	*H. D.* 172804	37.1	+ 6 43	Np	− 07	−.010	09	+.001	09	.010
165	*H. D.* 173291	39.4	+36 52	Nb	+ 10	+.012	09	−.002	10	.012
166	*S Scuti*	44.9	− 8 1	Nb	+ 12	+.018	08	+.003	07	.018
167	*UW Aquilæ*	52.0	+ 0 19	. .	+ 14	+.021	12	+.012	12	.024
168	*UV Aquilæ*	54.0	+14 14	Nb	+ 24	+.035	11	+.004	12	.035
169	*V Aquilæ*	59.1	− 5 50	Np	+ 09	+.013	05	+.005	05	.014
170	−16° 5272	19 13.4	−16 5	Na	+ 11	+.016	04	+.002	04	.016
171	−10° 5057	17.6	−10 54	Ro	+ 03	+.004	05	+.027	04	.027
172	*UX Draconis*	25.1	+76 23	Nb	− 27	−.009	01	+.002	04	.009
173	*AW Cygni*	25.8	+45 50	. . .	+ 07	+.007	10	+.063	13	.063
174	*AO Sagitt.*	28.6	−16 35	Nb	+ 10	+.014	07	+.006	06	.015
175	*R Cygni*	34.1	+49 58	Md	− 03	−.003	03	−.003	04	.004
176	*TT Cygni*	37.1	+32 23	Nb	− 03	−.004	07	+.009	09	.010
177	*T Pavonis*	39.5	−72 1	Md	− 07	−.003	04	−.010	10	.010
178	*Cygni*	46.7	+32 40	Mdp	− 60	−.076	12	−.054	10	.093
179	*S Pavonis*	46.8	−59 27	Md	+ 01	+.001	06	−.061	09	.061
180	*AX Cygni*	54.0	+44 0	Nb	− 21	−.023	04	−.012	05	.026
181	+9° 4369	56.3	+ 9 14	Nb	± 00	±.000	07	−.016	06	.016
182	+20° 4390	58.0	+20 49	Nb	− 04	−.006	08	−.010	09	.012
183	*X Sagittæ*	20 0.7	+20 22	Nb	+ 01	+.001	09	−.027	09	.027
184	*AA Cygni*	0.8	+36 32	Np	− 23	−.028	13	−.010	15	.030
185	*RS Cygni*	9.8	+38 28	N	− 06	−.007	04	−.013	04	.015
186	*RT Capricorn*	11.3	−21 38	N	− 21	−.029	07	−.022	08	.036
187	*U Cygni*	16.5	+47 35	R8	− 26	−.026	07	+.035	10	.044
188	*T Miscroc.*	21.8	−28 35	Md	+ 01	+.001	06	+.003	05	.003
189	*AD Cygni*	27.6	+32 14	Pec.	− 03	−.004	08	+.011	10	.012
190	*Y Aquarii*	39.1	− 5 12	.	+ 09	+.014	. . .	+.035	. . . . .	.038
191	*U Delphini*	40.9	+17 44	Md	+ 05	+.007	14	+.012	15	.014
192	*V Aquarii*	41.8	+ 2 4	Md	+ 02	+.003	09	−.007	09	.008
193	+45° 3271	43.4	+45 41	Pec.	+ 05	+.005	10	+.029	13	.029
194	*R Vulpeculæ*	59.9	+23 26	Md	+ 09	+.012	07	−.006	06	.013
195	*RS Capricorn*	21 1.7	−16 49	Me	+ 27	+.039	14	−.038	11	.054
196	*RX Aquarii*	7.3	−14 48	Me	+ 12	+.017	13	−.036	13	.040
197	*T Cephei*	8.2	+68 5	Md	− 79	−.043	02	−.038	08	.057
198	*R Equulei*	8.4	+12 23	Md	+ 23	+.034	13	−.016	11	.038
199	*T Indi*	13.6	−45 26	Na	+ 14	+.015	08	+.001	09	.015
200	*T Capricorn*	16.5	−15 35	Md	+ 10	+.014	. . . . .	−.024	. . . . .	.028
201	*YY Cygni*	18.6	+41 58	. . .	− 07	−.008	08	+.005	10	.009
202	+49° 3535	25.8	+49 54	. .	− 15	−.015	11	+.007	15	.017
203	*W Cygni*	32.2	+44 56	Me	+ 38	+.040	11	−.003	14	.040
204	*S Cephei*	36.5	+78 10	Pec.	+ 40	+.012	01	−.005	08	.013
205	+34° 4500	37.8	+35 2	Nb	+ 10	+.012	05	−.014	05	.018
206	*RV Cygni*	39.1	+37 35	N	+ 05	+.006	06	+.002	07	.006
207	+49° 3673	51.5	+50 1	Pec.	+ 23	+.022	06	+.002	08	.022

	★	α	δ	Sp.	μ_x	μ_x	p. e.	μ_δ	p. e.	μ
		h m	° ′		s	″	″	″	″	″
208	*RX Pegasi*	21 51.7	+22 24	Nb	+.0001	+.006	±.008	+.001	±.008	.006
209	*U Aquarii*	57.9	−17 6		+ 01	+.001	....	+.020	....	.020
210	+20 5071	59.7	+20 31	R3	+ 14	+.020	07	−.003	07	.020
211	*S Lacertæ*	22 24.6	+39 18	Md	+ 24	+.028	07	+.012	11	.030
212	+61 2132	40.4	+61 12	Nb	+ 16	+.012	07	+.013	12	.018
213	+53 3033	51.9	+53 41	Nb	+ 09	+.008	06	+.006	12	.010
214	*R Pegasi*	23 1.6	+10 0	Md	− 08	−.012		−.038	..	.040
215	*TY Andromedæ*	10.0	+40 15	Md	+ 18	+.021	07	+.002	09	.021
216	+9 5191 ...	11.8	+10 4	Me	+ 24	+.031	07	−.002	07	.031
217	*S Pegasi* ..	15.5	+ 8 22	Md	+ 57	+.084	15	−.048	14	.097
218	+48 4051	22.2	+48 58	Nb	− 11	−.011	07	+.013	11	.017
219	*R Aquarii*	38.6	−15 50	Md	+ 20	+.029	05	−.005	04	.029
220	19 *Piscium* .	41.3	+ 2 56	Na	− 30	−.045	01	−.020	01	.049
221	+5 5223 ...	44.0	+ 5 50	R3	+ 09	+.013	07	+.002	06	.013
222	*TZ Cassiopeiæ*	48.0	+60 27	Me	− 13	−.010	05	+.001	11	.010
223	*R Cassiopeiæ*	53.0	+50 50	Md	+ 75	+.071	03	−.002	05	.071
224	*S Phœnicis* ...	53.9	−57 8	Md	− 18	−.015	06	+.014	09	.021
225	+59 2810 ..	56.2	+59 48	Na	+ 18	+.014	03	−.003	06	.014
226	*SU Andromedæ*	59.4	+43 0	Nb	+ 12	+.013	07	+.024	09	.027

NOTES

6, 9, 11, 49, 67, 70, 72, 77, 81, 86, 122, 164, 175. Spectra are classified, S, by MERRILL.

54, 83, 143, 150, 190 and 209. Proper-motions were derived by MISSES YOUNG and FARNSWORTH[3].

105, 200 and 214. Proper-motions are the means of those derived by MISSES YOUNG and FARNSWORTH and WILSON.

178. Proper-motion taken from the *Preliminary General Catalog*, no later material being available.

187. Spectrum classified, Næ, by MOORE.[10]

TABLE II

	*	α	δ	Sp.	μ_x	μ_δ	μ
		h m	° ′		″	″	″
1	*T Androm.*	0 17.2	+26 26	Md	+.021	+.046	.051
2	*S Ceti*	19.0	− 9 53	Md	−.009	+.020	.022
3	*H. D.* 5223	18.9	+23 32	R	+.148	−.018	.149
4	*S Piscium*	1 12.3	+ 8 24	Md	−.031	−.028	.042
5	*H. D.* 10636	38.7	+53 28	R5	+.23:	+.07:	.240
6	*U Ceti*	2 28.9	13 35	Md	+.057	−.004	.057
7	*R Trianguli*	31.0	+33 50	Md	−.01.	.03:	.032
8	*H. D.* 16896	37.4	−23 2	Me	+.021	.016	.026
9	+57 647	43.6	+57 26		−.031	.013	.034
10	*R Persei*	3 23.7	+35 20	Md	−.049	−.056	.074
11	*H. D.* 24281	46.7	−13 50	R3	−.14:	.11.	.156
12	*V Eridani*	59.7	16 0	Me	±.00	.08:	.080
13	*R Fornacis*	4 7.3	25 21	Md	+.11:	−.02.	.112
14	*T Camelop.*	30.3	+65 57	R?	−.04:	.03:	.050
15	*T Cæli*	43.8	36 23	Nb	−.023	−.018	.029
16	+38 955	4 45.8	+38 20		+.039	−.022	.045
17	*V Tauri* ..	46.2	+17 22	Md	−.093	−.002	.093
18	*T Leporis* .	5 0.6	−22 2	Md	−.04:	−.01:	.041
19	*S Camelop.* .	30.2	+68 48	R8	−.064	+.008	.064
20	*H. D.* 37212.	31.7	−25 48	Na	+.132	−.010	.132
21	*H. D.* 38521	41.1	+41 50	Pec.	+.002	−.045	.045
22	*V Aurigæ* .	6 16.5	+47 45	Nb	±.000	−.21:	.210
23	*U Monocer.* .	17.7	− 2 9	Md	+.00:	+.01:	.010
24	*H. D.* 44653. .	17.8	+25 4	Nb	+.01:	−.01:	.014
25	*RV Aurigæ* .	27.6	+42 34	Na	−.02:	−.02:	.028
26	*H. D.* 48664	39.4	+ 3 25	Pec.	+.048	−.024	.054
27	*H. D.* 50136	48.2	− 4 27	Nb	+.04:	−.19:	.194
28	*H. D.* 53917.	7 1.7	−35 47	Me	−.002	+.020	.020
29	*H. D.* 57160	14.9	+25 10	Nb	+.054	−.005	.054
30	*H. D.* 60826	31.3	+ 2 18	Na	+.08:	−.04:	.089

	*	α	δ	Sp.	μ_α	μ_δ	μ
		h m	° ′		″	″	″
31	*H. D.* 62164	7 37.5	−10 39	Me	+.024	+.037	.044
32	*RU Puppis*	8 3.2	−22 37	Nb	+.057	+.027	.063
33	*H. D.* 70138	15.2	−17 57	R5	−.01:	−.03:	.032
34	*X Hydræ*	9 30.7	−14 15	Md	−.06:	+.01:	.061
35	*RS Hydræ*	10 46.6	−28 6	Md	+.07:	−.03:	.076
36	*R Corvi*	12 14.4	−18 42	Md	+.021	−.032	.038
37	*H. D.* 107913	18.9	−35 5	Me	−.06:	−.03:	.067
38	*S Centauri*	19.2	−48 53	R5	−.07:	+.03:	.076
39	*T Ursa. Maj.*	31.8	+60 2	Md	+.06:	+.05:	.078
40	*RW Hydræ*	13 28.8	−24 53	Md	+.01:	−.01:	.014
41	*R Can. Ven.*	44.7	+40 2	Md	+.051	−.047	.069
42	*RS Virgin.*	14 23.3	+ 5 8	Md	+.03:	+.03:	.042
43	*S Libræ*	15 15.6	−20 2	Md	−.18:	+.08:	.197
44	*H. D.* 137613	21.9	−21 49	Ro	+.004	−.005	.006
45	*RZ Scorpii*	58.6	−23 50	Md	+.04:	−.12:	.126
46	*RR Herculis*	16 1.5	+50 46	Md	+.028	+.14:	.143
47	*U Herculis*	21.4	+19 7	Md	−.169	−.013	.171
48	*ST Scorpii*	30.2	−31 2	R5	+.01:	−.01:	.011
49	*W Herculis*	31.7	+37 32	Md	−.011	+.036	.038
50	*R Draconis*	32.4	+66 58	Md	−.006	−.035	.036
51	*AX Scorpii*	35.6	−26 55	Me	+.05:	−.06:	.078
52	*S Herculis*	47.4	+15 7	Md	−.049	−.032	.059
53	*RS Herculis*	17 17.5	+23 1	Md	−.007	−.045	.016
54	*SX Scorpii*	40.8	−35 40	Nb	−.01:	+.02:	.022
55	*H. D.* 166097	18 4.0	+ 9 26	R5	±.00:	−.07:	.070
56	*H. D.* 168227	13.6	−15 39	R5	+.055	+.033	.064
57	*TY Ophiuchi*	26.4	+ 4 19	Nb	+.32:	−.03:	.321
58	*H. D.* 173409	40.0	−31 28	Ro	+.01:	±.00:	.010
59	*T Scuti*	50.0	− 8 19	Nb	−.019	−.002	.019
60	*RW Scuti*	51.0	−10 39	Me	−.07:	−.03:	.076
61	*H. D.* 175893	52.4	−29 38	R1	+.04:	−.05:	.064
62	*SU Sagittar.*	57.7	−22 51	Me	−.057	−.074	.093
63	*R Aquilæ*	19 1.6	+ 8 5	Md	+.001	−.068	.068
64	*U Draconis*	19 9.9	+67 7	Md	−.06:	+.05:	.078
65	*W Aquilæ*	10.0	− 7 13		±.00:	−.02:	.020
66	*T Sagittar.*	10.5	−17 9	Md	+.006	+.029	.030
67	*UW Sagittar.*	40.6	−18 24	Na	+.003	+.020	.020
68	*RT Cygni*	40.8	+48 32	Md	−.004	+.029	.029
69	*RR Sagittar.*	49.7	−29 27	Md	−.047	−.019	.011
70	*RU Sagittar.*	51.8	−42 7	Md	−.001	−.120	.120
71	−27° 14534	20 0.8	−27 31	Me	+.027	−.016	.029
72	*AY Cygni*	6.3	+41 12		−.078	±.000	.078
73	*SV Cygni*	6.5	+47 35	Nb	−.056	−.002	.056
74	−16° 5558	13.3	−16 10	Me	+.046	+.019	.050
75	*S Delphini*	38.5	+16 44	Me	−.03:	−.01:	.032
76	*T Aquarii*	44.7	− 5 31	Md	−.010	−.031	.033
77	*S Indi*	49.0	−51 42	Md	+.01:	−.05:	.051
78	*RU Cygni*	21 37.3	+53 52	Me	−.027	−.002	.030
79	*V Pegasi*	56.0	+ 5 38	Md	−.001	−.066	.066
80	*S Pisc. Aus.*	58.0	−28 32	Md	+.013	−.023	.026
81	*T Pegasi*	22 4.0	+12 3	Md	+.01:	−.04:	.041
82	*R Pisc. Aus.*	12.3	−30 6	Md	+.008	−.002	.008
83	−8° 5858	46.5	− 8 7	Md?	−.003	−.036	.036
84	*S Aquarii*	51.8	−20 53	Md	−.052	−.036	.063
85	*Y Sculptoris*	23 3.7	−30 40	Me	±.000	−.022	.022
86	*Z Androm.*	28.8	+48 16	Md?	+.087	−.043	.097
87	*Z Aquarii*	47.1	−16 25	Md	−.006	+.043	.043
88	*RS Androm.*	50.3	+18 5	Me	+.011	−.019	.022
89	*W Ceti*	57.0	−15 14	Md	+.04:	−.03:	.050

NOTES

11 and 66. Spectrum classified, S, by MERRILL.
29 and 67. Proper-motions by NORLUND.[4]

The mean proper-motions of the stars of the different spectral classes contained in the two tables are:

Class	μ	No.	Wt.
Md	0″.0455	121	95.7
Me, Md	.0435	158	124.2
R	.0299	34	24.8
Pec.	.0295	13	12.0
N	.0252	92	82.9
Unknown	.0350	18	15.7

Comparison with the similar tabulation in my earlier paper[1] shows that the increase in the number and weight of the proper-motions available has produced a decrease in the mean proper-motion for each type group.

Before considering the motions of these stars it is advisable to consider the necessities or justifications for possible rejections. An examination of the lists shows that of the 226 stars in Table I but two, the two brightest Md variables, *o Ceti* and L_2 *Puppis*, have total proper-motions exceeding 20″ per century. The three abnormal proper-motions in Table II are definitely unreliable. It has been the custom here to treat separately the stars with motions greater than or less than 20″ per century. Wherefore, we feel justified in rejecting from the solution for solar and stellar motions the five stars with proper-motions exceeding this amount, leaving 310 stars to be considered.

THE CLASS Md STARS

In all respects, save in the absence of bright lines and minor differences in their absorption spectra, the 37 Class Me stars listed in the tables are similar to those of Class Md. They were included because they are all variables and their motions are comparable with those of the Md stars.

Solutions for the coördinates of the solar motion referred to these stars give the following values:

[4] *Publikationer og mindre Meddelelser fra Kopenhavns Observatorium*, No. 9, 1912.

A	D	M	No.	Class
276°.9	+34°.0	0″.0204	119	Md
276 .7	+42 .3	.0202	156	Me, Md

These values are in notable accord with the coordinates, $A = 274°$; $D = +11°$, derived by MERRILL[5] from the radial velocities of 83 Md stars. As MERRILL's velocities depend upon the bright lines, which give results somewhat different systematically from the absorption lines, his solar speed may not be directly comparable with the values of the parallactic motion given above. If his value, −56 km. per second, does represent the true solar speed derived from these stars, their mean parallax must be about $\pi_m = 0''.00171$. If, on the other hand, we use the velocity derived by the writer from MERRILL's observations of 43 stars at Ann Arbor[6] reduced to a dark-line basis, $V = -36.5$ km. per second, $\pi_m = 0''.00262$. The mean of the two values is probably a closer approximation to the truth than either one; hence we adopt as the mean parallax of the Me, Md stars of this list: $\pi_m = 0''.0022$. The mean apparent magnitude of the stars is 7.4; the mean absolute magnitude is, therefore, approximately −0.9. At a distance of one Siriometer this magnitude would become −2.5, in agreement with the value −2.2 found by GYLLENBERG[7] for stars of this type. There can be little doubt that practically all of the stars of these types listed in Tables I and II are giants.

Solutions for the preferential motion of these stars give the following directions of and mean square motions along the axes of the velocity ellipsoid. The unit of motion is seconds of arc per century.

119 Md STARS

A_1	94°.1	D_1	+12°.3	λ_1	16″.02
A_2	351 .0	D_2	+46 .3	λ_2	7 .88
A_3	194 .8	D_3	+41 .0	λ_3	6 .40

156 Me, Md STARS

A_1	96°.1	D_1	+15°.9	λ_1	16″.58
A_2	350 .1	D_2	+43 .8	λ_2	7 .72
A_3	200 .8	D_3	+41 .6	λ_3	5 .58

Comparison with RAYMOND's values[8] of the velocity figure determined from all the stars of the *Preliminary General Catalog* shows that the velocity figure of the Me, Md stars agrees closely, not only with that of the M stars, but also with the figure derived from 5384 stars of all types with proper-motions less than 20″ per century. It is evident, therefore, that the Me, Md stars follow the general tendency of the stars of the more common spectral types in preferential motion towards KAPTEYN's vertex, the velocity ellipsoid being flattened toward the plane of the Milky Way.

THE CLASS N STARS

Before attempting any solution for the motions of the stars of this class, it was quite evident that the results must be seriously influenced, if not totally invalidated, by the peculiar distribution of the stars whose proper-motions have been determined. The number of stars in each two-hours of right-ascension, together with the mean declination, is given below.

R.A.	No.	Dec.	R.A.	No.	Dec.
1–2	4	+10	13–14	0	..
3–4	9	+26	15–16	3	−14
5–6	20	+17	17–18	12	−8
7–8	8	+2	19–20	13	+20
9–10	7	−12	21–22	6	+27
11–12	4	+38	23–0	6	+40

If we were dealing with radial velocities such a distribution would be exceptionally favorable for determining the solar motion. It is easy to see that when proper-motions are under consideration this distribution is most unfavorable as the great majority of the motions are across the line which it is proposed to determine. If we had two groups of stars lying near the equator, one at R. A. 6h, and the other at R. A. 18h, the right-ascension of the solar apex determined from the proper-motions should lie approximately half way between; that is, somewhere on the hour-circles thru 0 and 12 hours; while the declination would be indeterminate. With similar right-ascension and uniform distribution from pole to pole, the declination of the apex would become less uncertain but the right-ascension would still be indeterminate. The situation with which we are confronted is somewhat similar, 45 out of the 90 stars under consideration being concentrated in the two right-ascension groups at 5–6 hours and 17–20 hours. It is further complicated by the minuteness of the proper-motions with which we

[5] *Carnegie Institution of Washington*, Year Book, No. 20, p. 269, 1922.

[6] *Publications of the Detroit Observatory*, 2, 62, 1916.

[7] *Meddelanden fran Lunds Astronomiska Observatorium*, Series 1, No. 99, 1922.

[8] *Astronomical Journal*, 30, 197, 1917.

have to deal and the consequent possible effects of systematic errors. To these causes may be ascribed the differences between the directions of solar motion derived by various investigators[7,9,10]. The right-ascensions of the solar apex is essentially indeterminate.

Four solutions for the solar motion, based on the data in Tables I and II, have been made, with the following results:

A	D	No.	Method
340°	+35°	92	Bravais
331	+38	92	Airy
345	+37	92	Charlier, reduced motions
353	+26	90	Bravais, pm.'s < 20″
342°	+34°		Mean

The declination of the apex comes out unexpectedly near to the true position and is probably not far from what we should get were the distribution uniform. The right-ascension, as was expected, comes out 70°± from the true position and but 20°± from the plane at right-angles to the direction of solar motion. The parallactic motion derived from the solutions is $M = 0''.0052$. Altho all the values are decidedly uncertain, a comparison is made with the solar speed determined by Moore[10] from the radial velocity observations of 25 N-type stars, $V = -17.2$ km. per second. The resulting parallax of the group of 92 N stars is,

$$\pi_m = 0''.0014.$$

As the mean apparent magnitude of the stars is 7.9, the mean absolute magnitude is approximately −1.4. From 23 of the brighter stars of the group Moore gets −1.5; Laplau-Jansen and Haarh[9], using Norlund's[4] proper-motions, get −1.3; while Kapteyn[11], with the same data and assuming the apex at R. A. 270° and Dec. +30°, gets −2.6. The agreement among the first three values is most striking. All the investigators agree in assigning to the Class N stars a mean absolute magnitude greater than that of the Class B stars.

The points which we have already presented with regard to the effect of the distribution of this group of stars on the solar motion apply with equal force when we come to consider the preferential stellar motions. Inasmuch as the maxima in the number of stars lie nearly at the opposite ends of the axis of preferential motion, it must be obvious, *a priori*, that this axis will become the apparent axis of avoidance. The interesting question to be considered is, which of the other axis of the velocity ellipsoid will be the greater, that directed toward the pole of the Milky Way or the one in the Galaxy, ordinarily termed *the intermediate axis*. The solution for preferential motion gives the following results:

A_1	7°.7	D_1	+ 7°.8	λ_1	6″.95
A_2	123 .5	D_2	+73 .4	λ_2	4 .24
A_3	275 .5	D_3	+14 .9	λ_3	2 .60

While, as was expected, the apparent axes of the velocity ellipsoid make a considerable angle with what we consider to be the true directions of these axes, nevertheless it is clear (1) that the direction of preferential motion has become the apparent direction of avoidance and (2) that the pole of the Milky Way has become the apparent vertex of preferential motion. The writer is inclined to believe that this is largely due to distribution, altho an examination of the proper-motions in hourly groups shows that there is a possibility that the Class N stars, as a group, may be moving at right angles to the plane of the Milky Way. More proper-motions of stars situated in R. A.'s 21^h to 3^h and 9^h to 15^h are needed before this question can be settled; but it is quite obvious that no considerable number of stars of this type should be combined with stars of other types in determinations of either solar or stellar motions. In the solution for the preferential motions of the 151 red stars by the writer[1], 46 N stars were included, their weight being about a third the total weight of the stars used. The result was an apparent reversal of the minor axis of the velocity ellipsoid, the true intermediate axis being foreshortened and the axis of avoidance lengthened by the apparent peculiar motions of the N stars. When these stars are dropped from the solutions, the velocity figure of the remaining red stars approximates very closely that obtained from the stars of the other spectral types.

THE CLASS R STARS

The number of proper-motions available for the stars of this class makes any determination of solar or stellar motion uncertain. In view of the peculiarities found in the distribution and resultant motions of the Class N stars, however, it was deemed advisable to carry thru a solution for those of Class R to determine whether or not they might be properly included in a

[9] *Astronomische Nachrichten*, *218*, 388, 1921.
[10] *Lick Observatory Bulletin*, *10*, 167, 1922.
[11] *Astrophysical Journal*, *32*, 91, 1910.

combined solution for the remaining red stars. The results for solar and stellar motion follow:

A	269 .0	D	+14 .0	M	0″.0088
A_1	114 .5	D_1	− 7 .9	λ_1	11″.93
A_2	39 .1	D_2	+61 .3	λ_2	6 .87
A_3	200 .1	D_3	+27 .4	λ_3	3 .77

Considering the small number of stars the agreement of these results with those derived from the other stars is satisfactory and we may be reasonably certain that in their motions the stars of this class follow the tendencies of the stars in general. Radial velocities of 28 of these stars have been determined by SANFORD[5] at Mt. Wilson but, as they have not yet been published, no estimations of mean parallax or mean absolute magnitude can be made.

THE COMBINED SOLUTIONS

Neglecting the Class N stars for the reasons given above, solutions were made for the coördinates of solar and stellar motion based upon the 219 remaining stars listed in Tables I and II with proper-motions less than 20″ per century.

A	273 .5	D	+38 .0	M	0″.0165
A_1	98 .0	D_1	+11 .9	λ_1	14 .33
A_2	352 .4	D_2	+53 .3	λ_2	7 .69
A_3	195 .7	D_3	+34 .2	λ_3	5 .57

The results are in good agreement with those derived by RAYMOND[6] from proper-motions of 223 stars of Class M and from 5384 stars of all classes with proper-motions less than 20″ per century. These solutions are, of course, based largely upon the motions of the stars of Classes Me, Md and R and no conclusions may be reached with regard to the motions of the few stars with peculiar or unknown spectra. Their inclusion, in the final solution, however, produces no apparent change in the velocity figure, so that it is probable that their motions in the mean do not differ radically from those of the other red stars.

CONCLUSIONS

1. Essentially all of the 315 stars whose proper-motions are presented in this paper are giants and are extremely distant.

2. The stars of Class N present in their motions peculiarities which may in part be real but which are shown to be due in part, at least, to their peculiar distribution on the sky.

3. The direction of the solar motion indicated by the remaining red stars agrees closely with that derived from the proper-motions of the stars of other types.

4. These stars follow in their motions the tendencies of the stars of other types in preferential motion toward KAPTEYN's vertex, the velocity ellipsoid being flattened toward the plane of the Milky Way.

Dudley Observatory,
Oct. 6, 1922.

MICROMETER OBSERVATION OF BAADE'S COMET

By L. J. COMRIE

The following micrometer observation of BAADE's comet was made with the 24-inch refractor of the Sproul Observatory of Swarthmore College. The comet was faint, and the moonlight strong, so that the measures were difficult.

Date 1922 October $27^d.572$ G. M. T.
Comet − Star $+17^s.1$ $-2'\ 18''$
Correction for parallax $+0^s.40\ \Delta$ $+1''.9\ \Delta$.

The star was B. D. 35° 3970 or OΣ 398; it was not seen double. The position of the star for 1922.0 derived from the catalogues of Weisse-Bessel, Quetelet, Romberg and the *A. G. (Lund)* is

$$\alpha = 20^h\ 4^m\ 17^s.6 \quad \delta = 35°\ 29'\ 31''.$$

On the following night the comet was so faint and moonlight so strong that micrometer observations were impossible.

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ZENITH TELESCOPE LATITUDES.

By R. H. TUCKER.

In the results of observations with the zenith telescope the bisection errors are eliminated, with the permissable assumption that they are the same for equal distances north and south of the zenith point. Flexure errors, which should be very small, are also eliminated, and errors of the adopted refractions must closely balance. There should be but slight if any systematic errors, and the accidental errors of observation are those due to pointing on the star and the reading of the level.

The absolute latitude of a station from a single set of observations, made in one season of the year, can not be more precise than the declinations of the stars of the observing list. If the observations are continued through an entire year, it is possible to diminish the effect of the periodic term in errors of declination which depends on right ascension. Since the errors of the observations are included in this adjustment, the adjustment will not give perfect elimination of this periodic error of declination. The systematic error of declination which depends on the distance of a star from the celestial equator can not be effectually diminished by any subsequent treatment of these observations.

When the same list of stars is observed at one or more stations, during several years, the mean yearly results are not affected by the periodic errors in the adopted declinations. The proper motions are of prime importance, however, in drawing any conclusions in regard to relatively small changes in the position of a station on the surface of the earth, from astronomical observations.

A progressive change in the observed latitudes, such as has been recognized for the past twenty years in the results of the International zenith telescope stations, many have one of three general explanations. It may be due to chages of position on the surface of the earth.

It may be due to changes in the deviation of the pole of the earth, other than those deviations that are represented by the periodic revolution.

It may be due to a progressive change in the results of the zenith telescope observations.

A movement of the centre of gravity of the earth along the axis, which might be considered as a phase of the second explanation, is an hypothesis that has never been much favored. A progressive change in the deviation of the pole of rotation with respect to the pole of figure would appear as progressive changes in yearly values of latitude at the different stations, the changes would differ for the separate stations, and the coefficients of the periodic revolution of the pole would change from year to year at any fixed meridian.

As regards the third explanation there appears to be no source of instrumental error that could possibly account for similar results at so many stations. And the same conclusion must be reached for errors of observation, including those due to refraction. These are mainly accidental, and progressive changes can not be reasonably thus accounted for.

A systematic correction to the mean proper motion adopted for the stars of the zenith telescope list would represent the mean progressive change of latitudes, leaving the deviations from the mean rate of change to be accounted for by the errors of observations.

The computed proper motions adopted for the list of 192 stars for the northern stations, of mean declination $+39°$, have the following periodic character.

$$\mu\delta = -0''.012 - 0''.011 \sin \alpha$$

This corresponds to a parallactic effect of the solar motion of $0''.046$, for these stars of fifth to seventh magnitudes.

The *Kimura* or z term has been introduced in the computed variation of latitude to account for the mean progressive change in the results from all the stations. The computed yearly value was small for the first few years following the announcement of its detection in 1902, the yearly value has since been

increasing, and it is now close to 0″.1. The term is periodic, with a period of one year as determined here from the tabulation of monthly values. The uncertainty in the length of the period is slightly more than one day, for the computed value. The periodicity is analagous to that resulting from the treatment of the proper motions of a zone of stars. If the effect is distributed evenly over the interval of twenty years in which it has been augmenting, the average increase would be 0″.005 per year, with a periodic cosine term that appears to have the same size throughout.

Attributing the effect to proper motions, these would be increased in the mean to −0″.017, and the corresponding parallactic motion would be 0″.06.

The proper motions were undoubtedly computed with as much precision as the material permitted. Those of our various standard star systems show how large a divergence exists between the results reached by two authorities, for the best determined stars. The original system of AUWERS differs in mean proper motion from his new system by 0″.009, between the equator and +40°*. Between the new system of AUWERS and BOSS N.B.S. the difference is 0″.005. Between BOSS N.B.S. and P.G.C. the difference is 0″.003. The proper motions of AUWERS and NEWCOMB have no sensible systematic difference.

The declinations of the zenith telescope stars, if the original observations were of high quality, would reproduce the systematic errors of the standard stars with which they were reduced. If some of the original observations were of inferior quality, additional errors would be introduced. The computed proper motions are subject to these imperfections.

As the continued use of this list of stars has permitted an improvement in the declinations, through the correction of the periodic term depending on right ascension, such precise differential work may also give us a systematic correction to the adopted proper motions, that will improve the original values from meridian circle observations.

The corrected results may possibly be nearer the real figures than the proper motions of some of the stars of the list in BOSS P.G.C., as compiled by DR. SCHESLINGER.† The proper-motions of this catalogue may be as good as we have, but they are based on absolute declinations observed with the meridian circle, and they may be susceptible of improvement by refined differential tests.

A simple device was employed here more than a year ago to test the progressive changes in the zenith telescope results. These are published in monthly means for each station. The combination of fourteen consecutive values practically eliminates the corrections for the fourteen month term. Beginning each combination at the commencement of a calendar year, the mean of each includes an uncorrected residual for two months of the annual term. This residual is the same for all the combinations, and does not influence the computation of changes. The consecutive means overlap by two months — a slight advantage — and the computed means all differ from the true normal latitudes by a nearly constant amount.

The method eliminates the effects of latitude variation, in place of correcting the original values with the computed $\varphi - \varphi_0$. No assumption needs to be made as to the respective normal latitudes of the stations, nor do we need to assume that the coefficients of the periodic revolutions of the pole are constant from year to year. The computed values of the x and y coördinates for the meridian of Greenwich have always been found to differ, when the results from two or four stations, suitably situated, are contrasted with the mean results from all six stations. This difference should fairly be ascribed to the errors of observation. There has been a tendency to connect such divergences with peculiarities in the latitude variation at individual stations. Our method eliminates the corrections, and no assumption is required in favor of either explanation.

The only factor that is assumed to be constant is the length of the fourteen month period. My value from all the zenith telescope data since 1890 is 435 days. The period derived by CHANDLER, from the bulk of his discussion of earlier observations of all character, was 429 days. His last published period, from a limited number of sets of zenith telescope observations, about the epoch 1894, was 424 days. Recent very precise discussions of the International sets, following 1900, place the period between 432 and 433 days. Our method virtually uses the period of 426 days, but only a very small residual error is thus left in the means.

The following progressive changes have been thus computed from the detailed results, combined in fourteen consecutive values.

Station	Long.	Interval	Rate	Yearly v
Gaithersburg	77° W	1902 to 1913	+0″.0049	±0.018
Cincinnati	84 W	2 to 14	+0 .0052	040
Ukiah	123 W	2 to 20	+0 .0043	027
Mizusawa	141 E	2 to 16	−0 .0006	013
Tschardjui	63 E	2 to 13	+0 .0116	027
Carloforte	8 E	2 to 16	+0 .0026	012
Mean (6)	(14 years)		+0 .0047	±0.023
Average residual per station			±0 .0026	

*Astronomical Journal No. 809.

†Astronomical Journal No. 798.

The change in the declination system, 0″.03 in 1910, has been allowed for in computing the yearly rates. Also a change in the location of the instrument at Tschardjui, 0″.25 at the same epoch, has been deducted. The yearly residual r has been computed with the individual rate for each station.

There appears to be no legitimate reason for rejecting the results from any of the stations. Without the Turkestan station the mean rate would be +0″.0033, and the average station residual would be ±0″.0018. The yearly residuals for this station are close to the average. Cincinnati was a volunteer adjunct to the international scheme, and a smaller instrument was in use there, which may account for its larger accidental errors.

There is no evidence, in the results, of disturbances due to earthquakes. Carloforte, in Sardinia, and Mizusawa, in Japan, are in active areas. In Japan five hundred tremors of sensible character have been recorded in twenty years. Logically it would appear to have been unsuited for observations of latitude variation, as distinguished from changes of latitude. Actually its yearly residuals, and those of Carloforte are the smallest of the six stations. Californians are sensitive on this subject, and Ukiah may be left on the border line. The remaining three are fairly free from tremors.

If Ukiah is considered apart from the others, of course there is a progressive change that requires an explanation. If it is contrasted with Mizusawa and Carloforte only, as may be done from the diagrams published by Sir F. W. Dyson,* the rate differs from the mean of those two stations by 0″.003 per year. The diagrams do not represent the variation of latitude, but only the fourteen month oscillation. The increment of progressive change is however included. The remaining three stations were not illustrated, as the author stated, for economy of space.

The station at Ukiah has actually a rate very close to the mean rate of all six, and the three in this country are in noticeably close agreement. The combinations for Ukiah are here given in detail.

The values of observed φ have been compared with those computed with the rate +0″.0043, in column O — C. The increase in precision is not large, since the average is 6/7 of the average residual without rate.† The computed probable error of the rate from any one of the stations would be ±0″.002, and that of the mean of

Epoch	φ	Comp.	O — C
1902.6	12″.079	12″.107	−0″.028
3.6	122	111	+ 011
4.6	124	115	+ 009
5.6	111	120	− 009
6.6	111	124	− 013
7.6	114	128	− 014
8.6	089	132	− 043
9.6	155	136	+ 019
10.6	157	140	+ 017
11.6	156	144	+ 012
12.6	138	148	− 010
13.6	135	152	− 017
14.6	186	156	+ 030
15.6	239	160	+ 079
16.6	210	165	+ 045
19.6	156	178	− 022
20.6	104	182	− 078

Mean (17) (12.140)
Average r ±0.032 Average O — C ±0.027

all six would be ±0″.0008. This rate is the z term of the *International Bureau of Latitude*.

The observed φ may be scrutinized for evidence of disturbances from the earthquakes of 1903.6, 1906.3 and 1911.5. This can perhaps be done as effectively in the detailed monthly results of those years. The observed values have been corrected for $\varphi - \varphi_0$, in the following table, with the computed values for this longitude from all six stations at the same epochs.

Epoch	φ_0	Epoch	φ_0	Epoch	φ_0
1903.03	12″.07	1906.05	12″.06	1911.02	12″.16
11	08	10	09	12	17
19	05	18	11	19	15
26	04	26	11	25	15
33	06	32	09	32	12
40	04	40	05	39	10
48	06	48	10	48	11
56	04	56	08	57	12
67	02	67	05	67	11
78	04	78	03	80	10
90	06	89	09	89	13
97	08	97	07	96	12
Mean (12)	12.05		12.08		12.13
Av. r	± 0.02		± 0.02		± 0.02

The values for 1911 require a correction of −0″.03, to reduce them to the declination system of 1903 and 1906. The average error for a month, 0″.02, is smaller than the average error per year, in which the latitude

*Mon. Not. R. A. S., Vol. 78, p. 452, 1918.

†The increase is about as large as should be expected from the application of an average correction, ±0″.021, to an average error ±0″.032.

variation had been eliminated. This discordance, which is of much significance, is due to the fact that the computed corrections for $\varphi - \varphi_0$ in any year include the effect of the errors of observation of that year. When the corrections thus derived are applied to the observations of the same year, a closer agreement is naturally obtained than would be found if more precise and independent corrections for $\varphi - \varphi_0$ had been used. The closer agreement of the monthly values is partly fictitious.

There may be a question whether $\varphi - \varphi_0$ derived from an interval of twenty or thirty years — depending upon whether the material between 1890 and 1900 is used — is more precise than $\varphi - \varphi_0$ from the results of one year. If the coefficients of the rotation of the pole are constant, the longest interval gives the closest approximation to the true values of $\varphi - \varphi_0$. If the coefficients are variable, the yearly values are better. The special method used in deriving the mean yearly values above requires no assumption to be made regarding this question of invariability. The values of progressive change in the observed latitudes differ for the separate stations, as should be anticipated with the admitted lack of perfection in astronomical observations.

It does not appear to be necessary to account for the change by a shifting of the pole of rotation with respect to some fixed meridian, and it would be necessary to reject the resuts of one or more stations to do so satisfactorily. The complete material is none too extensive for all purposes, in this delicate problem, and the distribution of the stations is a prime requisite for its full solution.

If one explanation suffices, there is no need to divide upon two. Still less do we need to divide upon three, including a shift of position on the surface of the earth. There are sensible errors of observation in each result, and as long as differences do not exceed the limits of probable error it would require a special faculty of prescience to divide any particular difference into parts corresponding to error of observation, and to change of position.

The earthquake of 1906 gave us the only direct illustration of an actual shift of position on the crust of the earth, in modern times, as far as I am aware. No doubt exists that there was a displacement of points immediately adjoining the fault line, on the actual surface, of approximately twenty feet. I believe there is no such evidence for any other fault. Our astronomical observations give no clear indication that the position of the Lick Observatory meridian circle was changed at the epochs of the earthquakes of 1895, 1903, 1906 and 1911. Nor is there any indication that the instrument at Ukiah, which is 1°.6 of longitude west, and 1°.8 of latitude north of us, was changed in 1903, 1906 and 1911.

These observations do not give us any basis for adopting progressive changes, when the data are interpreted with due regard to the errors of declinations, and the results at other stations on the earth. Rates may be found by connecting high and low points, in any series of observations. Confirmation should depend on the distribution of intermediate and adjacent points. Sudden changes may be found between any two consecutive points, if we disregard the natural and inevitable errors of observation. The test of these changes is to be found in the criterion of errors.

Excessive refinement in the treatment of astronomical results may be misleading. Our instruments and our human faculties are fallible, and often systematic errors are of more significance than the accidental errors, with which we are more familiar.

Lick Observatory,
July 21, 1922.

UNIFORM CLOCK RATES FOR A PERIOD OF AN ENTIRE YEAR,

By M. L. ZIMMER.

The first series of fundamental observations made after coming to Córdoba early in 1913, pointed unmistakably to the fact that clock corrections obtained in the evening were larger than the corresponding ones obtained in the morning. The investigation of the cause of this, requiring as it does that the clocks be kept under strictly uniform conditions of temperature and pressure, led to the early construction of the new subterranean clock room.[1]

[1] *Astronomical Journal* No. 762.

In the article cited, it was stated that clocks running undisturbed under such conditions would be expected to give uniform rates for an entire year, and this expectation has been fulfilled. The two Riefler clocks Nos. 155 and 330 were installed in this room in the early part of 1919, the pendulum of Riefler No. 330 swinging in the meridian and that of No. 155 at right angles to it. Owing to several tests and experiments the room was not ready to be permanently closed until the following September and from that

time until about the end of October of the following year the clocks ran without any known disturbance, no one having even entered the room during that time; but from this date, for several months the clocks were rather frequently disturbed by earthquakes.

During this period about 15,000 observations were made for the further investigation of the night and morning phenomenon as well as to furnish the basis for the reduction of our fundamental observations of the full list of Boss' 1059 stars south of $+30°$. Also during that same period SEÑOR CHAUDET took time sets at more or less regular intervals for assuring exactness in the signals of the Argentine time service. No attempt was made to obtain an exceptionally high order of precision in these clock corrections.

A study of the graph together with a few trial tests showed that they would be represented by the following formula:

$$\Delta t_0 + at + bt^2 + c \sin 2 \odot + d \cos 2 \odot + e \sin 5 \odot + f \cos 5 \odot = \Delta t$$

Where

Δt_0 = mean clock correction.
t = No. of days from February 29.
$\odot$ = true longitude of *Sun* for date of observation.

Each clock correction then would form a conditional equation. Accordingly the following conditional equations were set up and solved by the method of least square:

Δt RIEFLER No. 330

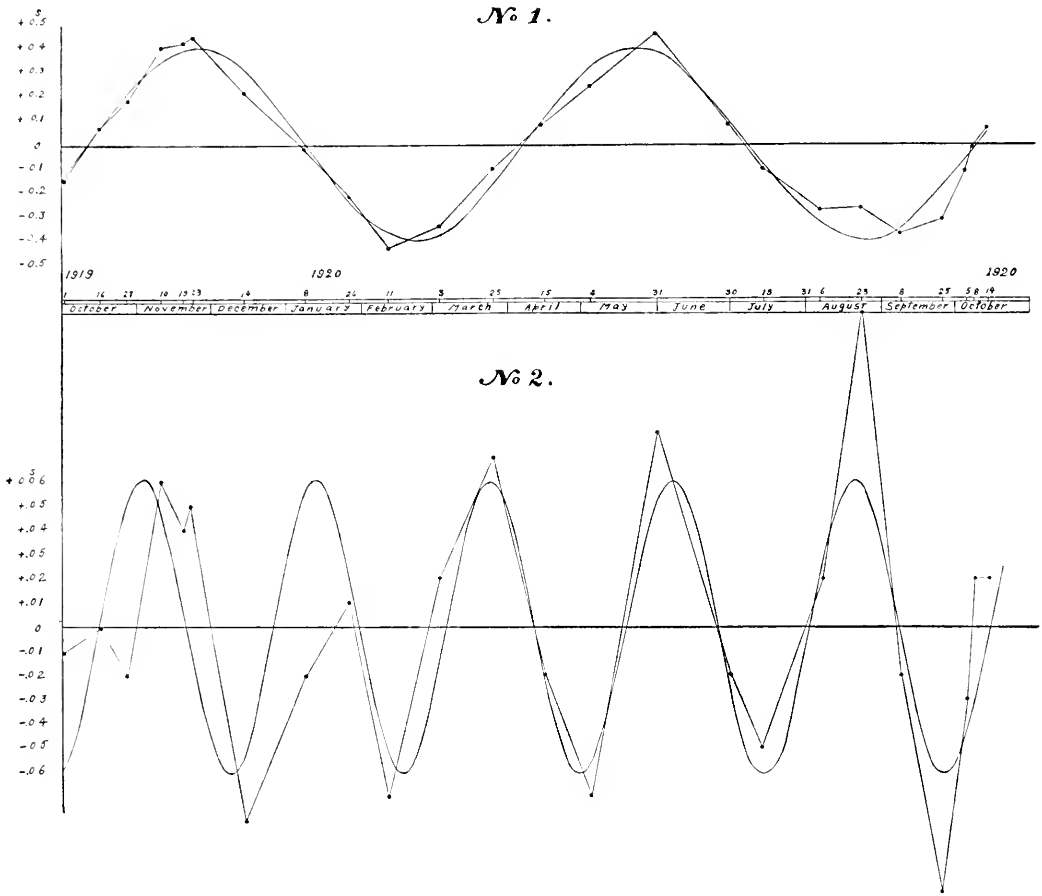
1919–1920											Chaudet O	C	O—C
											s	s	s
Oct.	1	Δt_0	$-151a$	$+22801b$	$+0.27c$	$+0.96d$	$-0.64e$	$-0.77f$	=		-0.06	-0.10	$+0.04$
	16	Δt_0	$-136a$	$+18496b$	$+0.71c$	$+0.70d$	$-0.92e$	$+0.40f$	=		-1.88	-1.88	.00
	27	Δt_0	$-125a$	$+15625b$	$+0.92c$	$+0.39d$	$-0.20e$	$+0.98f$	=		-3.20	-3.13	$-.07$
Nov.	10	Δt_0	$-111a$	$+12321b$	$+1.00c$	$-0.09d$	$+0.85e$	$+0.52f$	=		-4.75	-4.76	$+.01$
	19	Δt_0	$-102a$	$+10404b$	$+0.92c$	$-0.10d$	$+0.97e$	$-0.24f$	=		-5.82	-5.85	$+.03$
	23	Δt_0	$-98a$	$+9604b$	$+0.85c$	$-0.52d$	$+0.91e$	$-0.41f$	=		-6.28	-6.33	$+.05$
Dec.	14	Δt_0	$-77a$	$+5929b$	$+0.27c$	$-0.96d$	$-0.51e$	$-0.86f$	=		-8.91	-8.87	$-.04$
Jan.	8	Δt_0	$-52a$	$+2704b$	$-0.58c$	$-0.82d$	$-0.04e$	$+1.00f$	=		-11.78	-11.70	$-.08$
	26	Δt_0	$-34a$	$+1156b$	$-0.95c$	$-0.31d$	$+1.00e$	$+0.01f$	=		-13.74	-13.73	$-.01$
Feb.	11	Δt_0	$-18a$	$+324b$	$-0.98c$	$+0.21d$	$+0.25e$	$-0.97f$	=		-15.40	-15.38	$-.02$
Mar.	3	Δt_0	$+3a$	$+9b$	$-0.55c$	$+0.83d$	$-0.99e$	$+0.11f$	=		-17.08	-17.11	$+.03$
	25	Δt_0	$+25a$	$+625b$	$+0.18c$	$+0.98d$	$+0.44e$	$+0.90f$	=		-18.50	-18.51	$+.01$
Apr.	15	Δt_0	$+46a$	$+2116b$	$+0.78c$	$+0.62d$	$+0.78e$	$-0.63f$	=		-19.75	-19.74	$-.01$
May	4	Δt_0	$+65a$	$+4225b$	$+1.00c$	$+0.02d$	$-0.66e$	$-0.75f$	=		-20.72	-20.71	$-.01$
	31	Δt_0	$+92a$	$+8464b$	$+0.63c$	$-0.77d$	$-0.15e$	$+0.99f$	=		-21.89	-21.92	$+.03$
June	30	Δt_0	$+122a$	$+14884b$	$-0.31c$	$-0.95d$	$+0.71e$	$-0.71f$	=		-23.46	-23.47	$+.01$
July	13	Δt_0	$+135a$	$+18225b$	$-0.68c$	$-0.73d$	$-0.29e$	$-0.96f$	=		-24.08	-24.09	$+.01$
Aug.	6	Δt_0	$+159a$	$+25281b$	$-1.00c$	$-0.03d$	$-0.75e$	$+0.66f$	=		-24.86	-24.87	$+.01$
	23	Δt_0	$+176a$	$+30976b$	$-0.86c$	$+0.52d$	$+0.55e$	$+0.84f$	=		-25.14	-25.21	$+.07$
Sept.	8	Δt_0	$+192a$	$+36864b$	$-0.47c$	$+0.88d$	$+0.94e$	$-0.35f$	=		-25.43	-25.41	$-.02$
	25	Δt_0	$+209a$	$+43681b$	$+0.09c$	$+1.00d$	$-0.23e$	$-0.97f$	=		-25.45	-25.40	$-.05$
Oct.	5	Δt_0	$+219a$	$+47961b$	$+0.42c$	$+0.91d$	$-0.89e$	$-0.46f$	=		-25.25	-25.26	$+.01$
	8	Δt_0	$+222a$	$+49284b$	$+0.52c$	$+0.86d$	$-0.98e$	$-0.22f$	=		-25.14	-25.20	$+.06$
	14	Δt_0	$+228a$	$+51984b$	$+0.68c$	$+0.73d$	$-0.95e$	$+0.30f$	=		-25.03	-25.06	$+.03$
												pe	± 0.024

The following formula was obtained:

$$-16^s.495 \; -.0811t \; +.0001902\,t^2 \; +.3172 \sin 2 \odot \; -.2303 \cos 2 \odot \; +.0205 \sin 5 \odot \; +.0567 \cos 5 \odot = \Delta t.$$

With this formula clock corrections were then computed for the dates of observation and the column headed O — C shows how well the formula represents them.

The smooth curve No. 1 was computed from that part of the rate depending on $2\odot$ and the broken line, superimposed represents the observations freed from



that part of the rate depending on t and t^2. The smooth curve No. 2 was computed from that part of the rate depending on $5\odot$ and the broken line, superimposed upon it, represents the observations freed from that part of the rate depending on t, t^2 and $2\odot$.

The preliminary investigation of the more complete program made by Señor Guérin, which has about 400 conditional equations, shows that there are several curves of still shorter period superimposed on those two. Of course the effect of the change in longitude, produced by the latitude variations must be present. The complete formula, when the periodic and casual error of star places have been eliminated, will represent the observations with a probable error of less than half of that shown above. There can be no doubt about the reality of curve No. 1. Several causes have suggested themselves; but no attempt at an explanation is made at this time. Since both clocks traced out this same curve during the period, and from the fact that we have had glimpses of it from shorter periods of uninterrupted clock rates, we have every reason to suppose that it will be repeated in subsequent years. Should such be the case it will require explanation. The clocks have now been running under uninterrupted conditions since January 25th of the present year and should we be fortunate enought to finish out the year without interruption,* we should be in possession of data to settle this point.

The results need no comment, they speak for themselves. The test has been a severe one but the clocks have measured up to it in no uncertain way. I need hardly point out the value of such uniform rates. The value to fundamental work will be seen at a glance, since with such rates whole years' observations may be reduced in the same manner as those of a single night. Neither do I need to point out what new fields will be opened up for the study of gravitational problems and the possibilities of new discoveries.

Observatorio Nacional Argentino, Córdoba,
August, 1922.

ELEMENTS AND EPHEMERIS OF 1921 *W 19*,

By ERNEST CLARE BOWER AND ARTHUR NEWTON,

[Communicated by CAPT. W. D. MACDOUGALL, U. S. Navy, Superintendent of U. S. Naval Observatory.]

1921 *W 19* was discovered 1921, Nov. 21 by G. H. PETERS at Washington. Observations by him with a 10-inch triplet are as follows:

G. C. T.		Astrographic α 1921	δ 1921	ΔX	ΔY	ΔZ unit = 0.0000001	Est. Mag.	O − C $\Delta\alpha$	$\Delta\delta$
		° ′ ″	° ′ ″					″	″
(1)	1921 Nov. 21.97639	333 21 2.3	+ 9 35 16.9	−301	+141	−267	10.5	+ 0.3	−1.2
(2)	25.96944	334 33 40.4	+ 9 38 55.5	−304	+134	−267	10.5	+ 2.8	+1.1
(3)	29.96667	335 50 32.7	+ 9 44 48.1	−311	+118	−267	...	+ 5.8	+0.2
(4)	Dec. 1.97083	336 30 29.6	+ 9 48 35.3	−317	+ 99	−267	..	+ 3.6	−0.9
(5)	3.96667	337 11 24.9	+ 9 53 1.4	−318	+ 96	−267		+14.2	+4.3
(6)	9.95694	339 18 39.6	+10 9 15.8	−322	+ 83	−267	..	+ 3.3	+0.1
(7)	22.95278	344 17 48.5	+11 0 17.3	−332	+ 18	−267	.	0.0	0.0
(8)	27.96389	346 20 19.7	+11 25 16.8	−331	− 34	−267	..	+ 2.6	+6.2
(9)	1922 Jan. 2.96597	348 51 29.8	+11 58 27.4	−324	− 72	−267		+ 1.9	+1.4
(10)	7.95625	351 0 23.8	+12 28 39.8	−323	− 80	−267	..	− 4.1	−2.1
(11)	14.96944	354 6 13.8	+13 14 46.4	−300	−143	−267	. .	+ 3.3	0.0
(12)	24.98194	358 39 10.4	+14 26 35.6	−255	−213	−267	. .	0.0	+0.2
(13)	25.98917	359 7 7.0	+14 34 9.6	−241	−229	−267	. . .	+ 0.7	+0.4

An orbit by Leuschner's method, *Lick Pub.* **7**, was based on (1), (3) and (6). This was a two-solution case, the two roots being ρ = 1.91 and ρ = 0.20, but there was little difficulty in discarding the latter. The residuals of the direct solution were

	(1)	(6)
$\Delta\alpha$	$-30''.7$	$+41''.6$
$\Delta\delta$	$-\ 4\ .4$	$+\ 6\ .6$

A single correction, giving the second orbit, reduced these to zero.

The second orbit, with (7) as middle place, represented (1) and (2) for a first normal place and (12) and (13) for a third normal place as follows:

	(1)	(2)	(12)	(13)
$\Delta\alpha$	$-16''.7$	$-17''.5$	$+111''.4$	$+116.7$
$\Delta\delta$	$-\ 4\ .6$	$-\ 3\ .0$	$+\ 24\ .8$	$+\ 26.1$

A single correction, giving the final orbit and following elements, yielded the residuals tabulated above with the observations.

The parallax was treated as in *A. J.* **28**, 108 and as suggested in *A. J.* **34**, 29.

ELEMENTS AND CONSTANTS FOR EQUATOR

Epoch = 1921 Dec. 22.94026 G. C. T.

$$M = 14^\circ.73031 \qquad m_0 = 10.9$$
$$\mu = 0^\circ.2166784 \qquad g = 7.5$$
$$a = 2\ .745316$$
$$e = 0\ .202598$$
$$\left.\begin{aligned} i &= 15^\circ\ 56'\ 54''.9 \\ \Omega &= 286\ \ 17\ \ 24\ .3 \\ \omega &= 68\ \ \ 5\ \ 20\ .9 \end{aligned}\right\}\ 1921.0$$

$$\left.\begin{aligned} x &= .964593\ r \sin\ (\ 84^\circ\ 59'\ 41''.3 + V) \\ y &= .891341\ r \sin\ (347\ \ \ 0\ \ \ 4\ .3 + V) \\ z &= .524473\ r \sin\ (\ 21\ \ 20\ \ 46\ .7 + V) \end{aligned}\right\}\ 1921.0$$

This asteroid does not seem to be identical with any for which an orbit has been published. It has been named *Anacostia*.

1918–19 Ephemeris

G. C. T. 1918	α_{1921} h m		δ_{1921} ° ′		(r) ρ	m
Nov. 2	10 8.0		+ 3 39		(3.136)	12.7
12	10 15.8	7.8	2 10	89	3.273	12.6
22	10 22.3	6.5	+ 0 44	86	3.144	12.5
Dec. 2	10 27.2	4.9	− 0 38	82	3.011	12.4
12	10 30.5	3.3	1 55	77	2.878	12.3
22	10 31.9	1.4	3 5	70	2.748	12.2
1919 Jan. 1	10 31.1	0.8	4 4	59	2.626	12.1
11	10 28.1	3.0	4 52	48	2.517	12.0
21	10 23.1	5.0	5 26	34	(3.224)	12.0
31	10 16.2	6.9	5 44	18	2.352	11.9
Feb. 10	10 7.9	8.3	5 45	1	2.307	11.9
20	9 58.9	9.0	5 31	14	2.290	11.9
Mar. 2	9 50.1	8.8	5 3	28	2.303	11.9
12	9 42.2	7.9	4 26	37	2.346	11.9
22	9 35.8	6.4	3 45	41	2.411	12.0
Apr. 1	9 31.5	4.3	3 5	40	2.505	12.1
11	9 29.2	2.3	2 29	36	2.615	12.2
21	9 29.2	0.0	− 1 59	30	(3.285)	12.3

1920 Ephemeris

G. C. T. 1920	α_{1921} h m		δ_{1921} ° ′		(r) ρ	m
Mar. 16	11 38.5		−36 5		(3.130)	11.9
26	11 34.8	3.7	36 35	30	2.347	11.8
Apr. 5	11 28.5	6.3	36 47	12	2.219	11.7
15	11 20.1	8.4	36 36	11	2.174	11.6
25	11 10.6	9.5	36 3	33	2.122	11.6
May 5	11 1.1	9.5	35 8	55	2.096	11.5
15	10 52.2	8.9	33 55	73	2.100	11.5
25	10 45.2	7.0	32 31	84	2.128	11.5
June 4	10 40.5	4.7	31 4	87	2.179	11.6
14	10 38.2	2.3	29 42	82	2.250	11.6
24	10 38.6	0.4	−28 29	73	(2.974)	11.7

1921 Ephemeris

G. C. T. 1921	α_{1921} h m		δ_{1921} ° ′		(r) ρ	m
July 29	22 34.6		+ 9 52		(2.227)	9.9
Aug. 8	22 28.3	6.3	11 20	88	1.303	9.8
18	22 19.9	8.4	12 23	63	1.260	9.7
28	22 10.4	9.5	12 57	34	1.240	9.7
Sept. 7	22 0.9	9.5	13 2	5	1.241	9.7
17	21 52.9	8.0	12 43	19	1.265	9.7
27	21 47.5	5.4	12 7	36	1.309	9.8
Oct. 7	21 45.1	2.4	11 23	44	1.372	9.9
17	21 46.1	1.0	10 42	41	1.449	10.0
27	21 50.3	4.2	10 7	35	1.539	10.1
Nov. 6	21 57.2	6.9	+ 9 44	23	(2.192)	10.3

1922–23 Ephemeris

G. C. T. 1922	α_{1921} h m		δ_{1921} ° ′		(r) ρ	m
Aug. 23	6 54.1		+27 36		(2.637)	12.1
Sept. 2	7 9.9	15.8	26 53	43	3.136	12.1
12	7 24.5	14.6	26 6	47	3.016	12.1
22	7 37.9	13.4	25 16	50	2.946	12.0
Oct. 2	7 49.8	11.9	24 23	53	2.838	11.9
12	8 0.1	10.3	23 30	53	2.726	11.9
22	8 8.5	8.4	22 36	54	2.610	11.8
Nov. 1	8 14.9	6.4	21 47	49	2.489	11.7
11	8 19.0	4.1	21 0	47	2.372	11.6
21	8 20.5	1.5	20 17	43	2.261	11.5
Dec. 1	8 19.3	1.2	+19 39	38	(2.846)	11.4
11	8 15.3	4.0	19 7	32	2.072	11.4
21	8 8.6	6.7	18 39	28	2.004	11.3
31	7 59.7	8.9	18 16	23	1.961	11.3
1923 Jan. 10	7 49.4	10.3	17 54	22	1.946	11.3
20	7 38.9	10.5	17 36	18	1.963	11.3
30	7 28.9	10.0	17 18	18	2.009	11.4
Feb. 9	7 20.7	8.2	17 1	17	2.084	11.5
19	7 14.7	6.0	16 45	16	2.181	11.6
Mar. 1	7 11.4	3.3	16 30	15	2.304	11.7
11	7 10.6	0.8	+16 15	15	(3.030)	11.8
21	7 12.3	1.7	15 58	17	2.586	12.0
31	7 16.2	3.9	15 41	17	2.739	12.1
Apr. 10	7 21.9	5.7	15 21	20	2.895	12.2
20	7 29.3	7.4	14 59	22	3.052	12.4
30	7 37.9	8.6	14 32	27	3.204	12.5
May 10	7 47.5	9.6	14 2	30	3.352	12.6
20	7 58.2	10.7	13 26	36	3.492	12.7
30	8 9.4	11.2	12 44	42	3.621	12.8
June 9	8 21.2	11.8	+11 58	46	(3.158)	12.9

The above is volunteer work.

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ELEMENTS, EQUATORIAL COORDINATES, AND EPHEMERIDES OF BAADE'S COMET,

BY R. A. ROSSITER AND MISS H. M. LOSH.

The elements were computed from the three following observations:

1922 October 23.5777 G. M. T.	VAN BIESBROECK	Williams Bay
November 1.5759	BARNARD	Williams Bay
November 16.6406	MCLAUGHLIN	Ann Arbor

ELEMENTS

Time of perihelion passage	T	1922 October 25.99067 G. M. T.	
Perihelion minus node	ω	118° 17′ 19″.1	1922.0
Longitude of node	☊	220 29 33 .4	1922.0
Inclination	i	51 27 29 .3	1922.0
Logarithm of perihelion distance	log. q	0.353840	

EQUATORIAL CONSTANTS FOR 1923

$$x = r\,(9.935173)\sin(\ 56^\circ\ 18'\ 52''.2 + v)$$
$$y = r\,(9.979870)\sin(336\ \ 54\ \ 26\ .9 + v)$$
$$z = r\,(9.769938)\sin(\ 92\ \ 14\ \ 28\ .6 + v)$$

EPHEMERIS

1923 G.M.T.	α 1923.0	δ 1923.0	log. Δ	light
	h m s	° ′ ″		
Jan. 9.5	23 4 23.8	+18 46 36	0.415425	0.46
13.5	23 13 23.3	+18 19 8		
17.5	23 22 15.1	+17 54 22	0.434802	0.41
21.5	23 30 59.0	+17 32 10		
25.5	23 39 35.1	+17 12 20	0.453869	0.37
29.5	23 48 3.4	+16 54 46		
Feb. 2.5	23 56 23.8	+16 39 14	0.472393	0.33
6.5	0 4 36.8	+16 25 36		
10.5	0 12 42.4	+16 13 45	0.490204	0.29
14.5	0 20 40.6	+16 3 29		
18.5	0 28 32.8	+15 54 38	0.507156	0.26

The residuals for the middle place, taken in the sense observed value minus computed value, are

$$\Delta\lambda\cos\beta = -1''.8 \quad \Delta\beta = +1''.8$$

The corresponding residuals for the observation

November 9.5814 G. M. T. ROSSITER Ann Arbor

are $\Delta\alpha\cos\delta = -2''.5 \quad = -0^s.17 \quad \Delta\delta = -4''.6$

The observations used in computing the elements were corrected for parallax and aberration on the basis of preliminary elements computed by PROFESSOR HUSSEY and students and the writers at Ann Arbor from observations of Oct. 22, Oct. 23, Oct. 24, and Oct. 27.

The light is computed on the basis of unity for Oct. 23, the date of the first observation used in computing the elements.

The elements do not seem to be similar to those of any set computed since 1890.

Detroit Observatory,
Dec. 7, 1922.

OBSERVATIONS OF BAADE'S COMET,

MADE AT ANN ARBOR WITH THE 12¼-INCH REFRACTOR OF THE DETROIT OBSERVATORY.

By R. A. ROSSITER and D. B. McLAUGHLIN.

Date	G. M. T.	Δα	Δδ	Comp.	App. α	App. δ	log pΔ		★	Obs.
	h m s	m s	′ ″		h m s	° ′ ″				
Oct. 24	17 9 51	+0 9.17	−4 43.2	13, 16	19 58 2.86	+36 18 14.5	9.6530	0.4174	1	R
27	15 6 27	+0 24.05	−3 41.9	13, 16	20 1 53.51	+35 26 21.4	9.6686	0.4744	2	R
27	15 35 2	+0 26.88	−4 3.4	12, 13	20 1 56.34	+35 25 59.9	9.6826	0.5014	2	M
Nov. 9	12 28 46	+0 28.42	+0 17.6	14, 17	20 35 38.51	+31 43 30.1	9.2974	0.2669	3	R
9	13 32 24	+0 31.88	−0 28.0	12, 15	20 35 41.97	+31 42 44.5	9.5079	0.3708	3	M
9	13 57 14	+0 37.46	−0 44.6	14, 14	20 35 47.55	+31 42 27.9	9.5585	0.4133	3	R
16	15 22 29	+0 21.65	+8 6.5	10, 12	20 53 16.00	+29 43 37.4	9.6693	0.5974	4	M
Dec. 8	12 49 52	−0 5.12	−6 30.4	14, 17	21 48 13.72	+24 13 16.6	9.5848	0.5784	5	R

Mean Places for 1922 of Comparison Stars

★	α	Red. to App. Pl.	δ	Red. to App. Pl.	Authority
	h m s	s	° ′ ″	″	
1	19 57 51.86	+1.83	+36 22 25.4	+32.6	*A. G. Lund* 8930
2	20 1 27.62	+1.84	+35 29 30.7	+32.6	*A. G. Lund* 9036
3	20 35 8.16	+1.93	+31 42 40.4	+32.1	*A. G. Leiden* 8377
4	20 52 52.36	+1.99	+29 34 58.9	+32.0	*A. G. Cambridge* 11922
5	21 48 16.65	+2.19	+24 19 16.9	+30.1	*A. G. Berlin B* 8432

R. A. Rossiter = R. D. B. McLaughlin = M.
The reductions of all of the observations were made by R. A. Rossiter.

THE VARIATION OF LATITUDE AT LICK OBSERVATORY,

By R. H. TUCKER.

In deriving the corrections for the variation of latitude at this Observatory, from the results of the zenith telescope observations at many stations, some features of general significance have been developed. These features would be similar for any other point on the *Earth*, and they may be traced in a general way in the x and y coördinates of the pole at Greenwich.

Before the establishment of the International zenith telescope stations there had been a vigorous campaign of latitude observations, in the last decade of the last century. Over twenty observatories took part in this campaign, each practically independently, and no one contributing with an interval of sufficient length to fix the period of the fourteen month term with precision. This is, in fact, the most difficult factor to establish. The early observations, preceding 1890, had been thoroughly discussed by Chandler, and his results have not been included in these computations, partly because they precede our own meridian circle observations.

The x and y coördinates, computed for the meridian of Greenwich from the observations at all the zenith telescope stations, have the following mean values and average values, in intervals of six years each.

Interval	Mean x	Average	Mean y	Average
1890 to 1895	0″.00	±0″.10	0″.00	±0″.10
1896 to 1901	.00	.09	+ .01	.09
1902 to 1907	.00	.10	+ .04	.10
1908 to 1913	+ .02	.16	+ .01	.15
1914 to 1919	+ .04	.16	+ .02	.15
Means	+0 .01	±0 .12	+0 .02	±0 .12

The maxima are $+0''.33$ and $-0''.30$ for x, and $+0''.35$ and $-0''.27$ for y.

There would seem to be a lack of symmetry in the rotation of the pole. This may be due to changes in the deviation of the axes. It may be due to errors in the declinations adopted for the stars of the International observing list, including proper-motions as an essential part of the declination system. Or the effect may be due to errors of observation. Sensible accumulation of mean differences begins with the installation of the International stations. The *Kimura* or z term had been computed separately, by the *Bureau of Latitude*, for the results following the year 1900.

The computed mean yearly values of this term, with its average monthly values are given in the following table. The term has a periodic character, of the form, $-0''.035 \cos (t - 1900.46)\ 360°$. In this, and in subsequent expressions, t is reckoned in years. The periodic term accounts for a large part of the average monthly residual. The column of computed yearly values of z has been formed by applying a rate of $+0''.005$ per year, with the epoch 1905. The average O − C, $\pm 0''.015$, is two thirds the size of the average yearly residual without a rate.

z Term

Epoch	Mean	Average	Comp.	O − C
1900.5	$+0''.003$	$\pm 0''.023$	$-0''.021$	$+0''.024$
1.5	+ 4	28	16	+ 20
2.5	− 6	21	11	+ 5
3.5	+ 12	21	6	+ 18
4.5	+ 19	25	− 001	+ 20
5.5	− 10	30	+ 004	− 14
6.5	− 21	12	9	− 30
7.5	− 17	39	14	− 31
8.5	+ 5	27	19	− 14
9.5	+ 21	35	24	− 3
10.5	+ 22	24	29	− 7
11.5	+ 30	36	34	− 4
12.5	+ 22	30	39	− 17
13.5	+ 32	31	44	− 12
14.5	+ 77	77	49	+ 28
15.5	+ 51	51	54	− 3
16.5	+ 56	58	59	− 3
17.5	+ 83	83	64	+ 19
Means	+0 .021	(±0 .038)	+0 .021	±0. 015

Yearly residual ±0.022 Monthly residual ±0.028

The $\varphi - \varphi_0$ for the longitude of this Observatory, computed from the x and y coördinates only, has the following mean values and average values, for intervals of six years.

Interval	Mean	Average
1890 to 1895	$0''.00$	$\pm 0''.11$
1896 to 1901	00	10
1902 to 1907	+ 03	10
1908 to 1913	+ 04	15
1914 to 1919	+ 04	13
Means	+0 .02	±0 .12

The maxima are $+0''.39$ and $-0''.27$.
The largest difference in a tenth of a year is $0''.19$.

These quantities are naturally nearly identical with the mean values of x and y at Greenwich. Dividing $\varphi - \varphi_0$ into 30 yearly sums, the average yearly mean is $+0''.017$, and the average residual from this mean is $\pm 0''.028$ per year. Dividing into 30 sums of 1.2 years each, beginning at the commencement of a calendar year, the average mean is $+0''.013$, and the average residual is $\pm 0''.016$ per interval of 1.2 years. These small mean values indicate the effect of variation of latitude on the yearly means of observations, and on the means of intervals of fourteen months.

The most pronounced term in the tabulated $\varphi - \varphi_0$ has an approximate period of 1.2 years, and five such periods would be included in six years. A more precise value, derived after applying the corrections for the annual term, is 1.19 years, and 21 periods would be completed in 25 years. Summing up $\varphi - \varphi_0$ in twelve groups of 21 values each, interpolating for intervals of 1.19 years, the corrections for the annual term are eliminated in the group means, and this is true whether the radius of the annual term is constant or variable. The coefficient of the long term, approximately fourteen months, is thus derived independently of any assumption other than that of a period of uniform length. Two overlapping summations are represented in the following expressions, for intervals of 25 years, 1890 to 1914, and 1895 to 1919. The maximum amplitude of $\varphi - \varphi_0$ is evidently $0''.23$, from the periodic variation.

$$\varphi - \varphi_0 = +0''.015 - 0''.156 \cos (t - 1890.76)\ 302° - 0''.071 \cos (t - 1890.83)\ 360°$$

$$\varphi - \varphi_0 = +0.020 - 0.157 \cos (t - 1895.52)\ 302° - 0.077 \cos (t - 1895.85)\ 360°$$

The details of one summation of the term of 1.19 years

follow. The column of computed $\varphi - \varphi_0$ has been derived from the expression above.

Limits	$\varphi - \varphi_0$	v	Comp.	O — C
1890.0 to 1913.8	$+0''.114$	$+0''.099$	$+0''.120$	$-0''.006$
90.1 to 13.9	+ 168	+ 153	+ 163	+ 5
90.2 to 14.0	+ 173	+ 158	+ 168	+ 5
90.3 to 14.1	+ 130	+ 115	+ 130	0
90.4 to 14.2	+ 059	+ 044	+ 063	− 4
90.5 to 14.3	− 020	− 035	− 018	− 2
90.6 to 14.4	− 095	− 110	− 090	− 5
90.7 to 14.5	− 134	− 149	− 133	− 1
90.8 to 14.6	− 136	− 151	− 138	+ 2
90.9 to 14.7	− 091	− 106	− 100	+ 9
91.0 to 14.8	− 031	− 046	− 033	+ 2
91.1 to 14.9	+ 048	+ 033	+ 048	0
Means	$+0\ .015$		$+0\ .015$	
Averages		$\pm 0\ .100$		$\pm 0\ .003$

Details of the similar computation of the annual term follow. Corrections for the longer term were first applied to $\varphi - \varphi_0$. These corrections would be eliminated in the summation of the original $\varphi - \varphi_0$, but, by applying them, the length of the period can be derived. This is found to be one year, with a probable error of half a day. The ten groups have 25 values each. The column of computed values is derived from the corresponding expression for the 25 year interval.

ANNUAL TERM

Epoch	Diff.	Comp.	O — C
0.0	$-0''.038$	$-0''.034$	$-0''.004$
0.1	+ 8	+ 9	− 1
0.2	+ 50	+ 48	+ 2
0.3	+ 71	+ 70	+ 1
0.4	+ 62	+ 65	− 3
0.5	+ 34	+ 34	0
0.6	− 6	− 9	+ 3
0.7	− 44	− 48	+ 4
0.8	− 70	− 70	0
0.9	− 68	− 65	− 3
Mean	$0\ .000$		
Averages		$\pm 0\ .045$	$\pm 0\ .002$

The computed values for the group means differ from the observed values by about four per cent of the average correction, in each computation. The computed probable error of a monthly $\varphi - \varphi_0$ would be $\pm 0''.015$, based upon these tabular results. The actual errors are much larger.

There are two definite explanations for this discordance. Either the radii of the revolutions traced by the pole are subject to variations in length, which are eliminated in the mean values for an interval of 25 years; or the observations of each year may be subject to systematic errors, which are eliminated in the same interval.

The average difference between the $\varphi - \varphi_0$, for tenths of a year, and the $\varphi - \varphi_0$ computed by the formula, is $\pm 0''.040$, for the interval of 30 years. Of 300 residual differences, 125 are plus, 150 are minus, and 25 are zero. There are 147 that exceed the probable error, $\pm 0''.035$. There are 52 that exceed twice the probable error, and the law of distribution of accidental errors allows 50. There are 24 that exceed three times the probable error, while theory allows 12. There is a run of high plus residuals in 1909, 1910 and 1911, and 12 of these large residuals, including the two largest, occur in that interval. There are 3 that exceed four times the probable error, $+0''.15$, $-0''.15$ and $+0''.17$, while theory allows 2. The largest does not exceed five times the probable error. A series of residual errors could hardly be expected to follow the distribution more closely. There is no essential variation in the size of the residuals at different epochs, except for the run of high individual differences noted above.

Correcting $\varphi - \varphi_0$ for the mean annual term, the individual period, epochs, and coefficients of the longer term have been computed. There are two zero points in each revolution, from which the length of the period can be determined more exactly than by attempting to fix the maxima and minima. The period ranges from 1.08 to 1.27 years, and the mean value is 1.192 yaers, or 435 days. The average residual of single periods is ± 0.03 year, and the probable error of the mean is ± 0.001 year, or less than half a day. The daily velocity of rotation is $0^\circ.827$, and the yearly velocity is 302°. The individual values of the computed epochs and coefficients follow. The principle of elimination of errors has necessarily been abandoned, in making these solutions for single revolutions of each term.

The probable error of an epoch, in the above computation, is ± 0.03 year. The high coefficients in 1909, 1910 and 1911 partly account for the run of large residual differences in the observed $\varphi - \varphi_0$. The probable error of the mean, $-0''.163$, is $\pm 0''.006$.

There is an apparent periodic character in the above coefficients, which could be represented by the expression, $+0''.05 \cos (t - 1900)\ 14^\circ.3$, with a period of 25 years. The application of such a periodic correction diminishes the average residual difference to $\pm 0''.025$ per revolution or 5/8 of the average residual

above. Since only one complete 25 year period is covered by the observations, the solution is not conclusive, and the residual differences may be merely systematic errors of observation.

Fourteen Month Term

Epoch	Coef.	Epoch	Coef.
1890.78	$-0''.22$	1905.10	$-0''.13$
91.86	19	6.19	12
93.14	13	7.37	15
94.32	12	8.48	22
95.51	12	9.77	22
96.72	14	10.95	23
97.95	12	12.15	25
99.14	15	13.10	21
1900.33	14	14.58	16
1.50	15	15.81	21
2.65	09	16.91	22
3.91	12	18.03	14
		19.40	13
		Mean	$-0\ .163$
		Average residual	$\pm 0\ .039$

Correcting $\varphi - \varphi_0$ for the mean long term variation, the period, epochs and coefficients of the annual term have been computed, as below. It appears to be worth while to develop these details of the latitude variation, for the reason that they apply equally well for any other station. The coefficient and epoch of

Annual Term

Epoch	Coef.	Epoch	Coef.
1890.79	$-0''.07$	1905.84	$-0''.05$
91.78	09	6.91	07
92.80	06	7.97	04
93.84	07	8.81	04
94.90	07	9.81	06
95.78	07	10.82	11
96.86	10	11.84	10
97.85	07	12.83	07
98.85	06	13.89	07
99.85	06	14.85	06
1900.80	06	15.81	08
1.86	07	16.85	09
2.83	08	17.81	07
3.86	07	18.85	10
4.85	06	19.83	07
		Mean	$-0\ .071$
		Average residual	$+0\ .011$

the annual term however vary with the longitude of a station.

The probable error of a single epoch is ± 0.025 year, in the above computation.

The average differences between the observed $\varphi - \varphi_0$ at tenths of a year, and the $\varphi - \varphi_0$ computed from single revolutions is $\pm 0''.012$ for the annual term, and $\pm 0''.020$ for the longer term. Both averages would be diminished by applying for each year the corrections derived for each term in that year.

The expression adopted for this station, from the zenith telescope observations of the past thirty years, is,

$$-0''.16 \cos (t - 1890.76)\ 302^\circ$$
$$- 0''.07 \cos (t - 1890.84)\ 360^\circ$$

If the revolutions of the pole are uniform in periods and radii, the average difference between the observed $\varphi - \varphi_0$ at tenths of a year and the computed $\varphi - \varphi_0$ is $\pm 0''.04$. If periods, epochs and radii vary, according to the figures in the preceding tables, the average difference between observed and computed $\varphi - \varphi_0$ does not much exceed $\pm 0''.01$.

This last figure represents a fictitious precision for the results of observation, since the errors of observation have been smoothed out by the application of the corrections derived from the observations of each year separately. Still closer apparent agreement would be reached by correcting the results at each station by a formula derived from the observations of a single year, or a fourteen month interval, at that station only.

This fictitious agreement has perhaps led to the proposal to determine the variation of latitude at each station, individually. The proposal evidently overlooks the need of correcting for the errors of star declinations, which depend on right ascension. These would directly influence the seasonal results of latitude observations. They are eliminated in the comparison of the results at two stations, suitably situated in longitude, when the same stars are observed at both. Until we have declinations superior in quality to those of our present standard star systems, no single station can determine the variation of latitude with more precision than that reached by the combination of several. Changes of latitude, as distinguished from latitude variation, may be studied in the differential results at single stations. But the accidental errors of observation should be considered, in interpreting such studies.

The most natural assumption is that such a periodic phenomenon as the variation of latitude would be

uniform in character, unless there is unimpeachable evidence to the contrary.

The fact that errors in the observed $\varphi - \varphi_0$ have been admitted by the *Bureau of Latitude* to be as large as a tenth of a second, supports the evidence of these tests.* Such an error might be expected to occur about once in two years, if accidental in character.

The last computation by the late DR. S. CHANDLER, for the latitude variation at any station, had the following form.†

$$\varphi - \varphi_0 = -0''.16 \cos [\lambda + (t - 2411790)\, 0^\circ.85] - r_2 \cos (\odot - G)$$

In this formula t is reckoned in days, and the epoch corresponding to the Julian period is February 25, 1891, which is in close agreement with the epoch of the long term from the zenith telescope results of the past thirty years. The coefficient of the so-called fourteen month term is the same. The daily velocity, $0^\circ.85$, corresponds to a period of 424 days, or 1.16 years, and the yearly velocity would be 310°. The value of r_2 for this station is $0''.14$, and of G, 197°. This coefficient is $0''.07$ larger than the one fixed by our computations, and the epochs of the annual term differ by 0.06 year. Periodic errors in the adopted declinations have the most direct influence in the computations for an annual term. With the use of his formula, the observed $\varphi - \varphi_0$ is represented with an average difference of $\pm 0''.03$, up to 1896. In the six years following, the average rises to $\pm 0''.13$, which is larger than the average $\varphi - \varphi_0$. The divergence becomes more marked for later years. The change of $0^\circ.023$ in daily velocity, or 8° in yearly velocity, has the effect of completely reversing the algebraic signs of the corrections for the fourteen month term, in an interval of about 22 years.‡ Introducing the value of the daily velocity, $0^\circ.83$, in his formula, in place of $0^\circ.85$, the average difference of his values from the observed values, at tenths of a year, is $\pm 0''.05$, throughout. His corrected values differ from those computed here by $\pm 0''.04$, in the same interval. The period which best represented the bulk of his earlier investigations was 429 days, with a daily velocity of $0^\circ.84$, and a yearly velocity of 307°.

Our meridian circle observations of latitude were discussed two years ago, for latitude variation. Up to the close of the last century, CHANDLER corrections had appeared satisfactory, as included in our published results. Details of our computations may be given later, and a brief statement of the results is sufficient for presentation here. Owing to gaps in the sequence of monthly results, the period of the long term could not be well fixed, and the approximate value 1.2 years was adopted, for summations similar to those used here for the zenith telescope results. The distribution of the values, at tenths of a year, was fairly uniform. For the annual term, the ten groups have from 14 to 17 each, with an average of 16. The twelve groups for the longer term have from 12 to 14 each. Corrections for the long term having been computed, and applied, the corrections for the annual term were derived. These were applied to the original latitudes, and corrections for the longer term were then determined anew. These gave the same expression as before for the annual term, and no further approximation was necessary to make up for the unsymmetrical distribution of the original material. There was an interval of 25 years, 1893 to 1918, available for the alternate elimination of each series of corrections. The elimination is not perfect, owing to the gaps in the separate years.

The system of declination adopted was not the same throughout, but as each system was in use at least a year, the monthly residuals are not much affected by the mean declination correction to each system. The expression following was derived from the latitudes given by the half sums of the observations of circumpolar stars, and of fundamental stars, in general south of the zenith.

$$\varphi - \varphi_0 = +0''.01 - 0''.13 \cos (t - 1894.3)\, 300^\circ - 0''.08 \cos (t - 1893.8)\, 360^\circ$$

The coefficient of the long term is $0''.03$ smaller than that derived from the zenith telescope observations, and the coefficient of the annual term is $0''.01$ larger. The epochs are in approximate agreement. The probable error of a single φ_0 was $\pm 0''.10$, from comparison with this expression. The probable error of the latitude from the observations of a single night does not exceed this figure, if only the accidental errors of observation are considered. But the results for any night are subject to certain systematic errors, of which the error of the nadir readings may be quoted as a specific case. Single settings on the nadir have about the same accidental errors as the observation of a star, since the circle reading is employed in each. The average error of the determination of the zenith point is between $0''.1$ and $0''.2$ per night, from one, two or three nadirs, depending on the length of the observing period.

*Wanach *Astr. Nach.* 4858, 1916.
†*Astronomical Journal* No. 330, 1894.
‡*Lick Obsy. Bull.* No. 323, 1919.

In zenith telescope observations there is undoubtedly a source of error in the readings of the level, and in the performance of the bubble. This may be accidental in nature, as regards individual readings, but is systematic in its effect on the mean results of a night. It possibly explains the discordance, which has been often noted by zenith telescope observers, between the apparent precision of individual observations and the ultimate precision of the mean of a night.

A separate solution of the latitude variation was made, from our circumpolar observations only. The weight of individual residuals is smaller than in the solution above, since but four circumpolar stars were usually observed each night, while the fundamental stars observed average at least twice that number. Some systematic errors are also eliminated in the combination of obervations north and south of the zenith, and these errors may not be constant. The circumpolars give the following expression for the same interval of 25 years, with over one thousand nights included.

$$\varphi - \varphi_0 = -0''.19 \cos (t - 1894.2)\, 300^\circ$$
$$- 0''.14 \cos (t - 1893.8)\, 360^\circ$$

Both coefficients are larger than those derived from our more complete material. The probable error of a single φ_0 is $\pm 0''.20$, or double the size of that from the combination of stars north and south of the zenith, and the respective weights would be one to four.

The astronomical latitude, based on the system of Auwers, is $37^\circ\ 20'\ 25''.6$ ($\pm 0''.01$), and there is no definite indication of any change in φ_0 in the past quarter of a century.

Lick Observatory,
August 2, 1922.

STELLAR PARALLAXES AND THE ECLIPSE OF 1922 SEPTEMBER 20,

By L. J. COMRIE.

When the plates secured during the recent eclipse for the testing of Einstein's theory are measured and compared with the check plates taken a few months previously it will be necessary to take into account every possible source of disturbance of the mean positions of the stars. Differential refraction and aberration will naturally be considered and allowed for. A number of the stars have large proper-motions, which cannot be neglected. But perhaps the most subtle source of systematic error will be the annual parallaxes of the stars, for very little is known about these. The displacement from mean position on the day of the eclipse will be practically zero, whereas in June or July, when the check plates were taken, the displacement may even be a little greater than the annual parallax — *greater* because the *Earth* was then near aphelion. Since corrections of the order of $0''.01$ will be applied in the reductions it is evident that our lack of knowledge of the parallaxes of the stars photographed is going to affect slightly the quantitative, though perhaps not the qualitative, result of the measures and reduction. To wait several years while the trigonometrical parallaxes of these stars are obtained is not necessary if it were possible for the Mt. Wilson or other observers to obtain spectrograms and deduce spectroscopic parallaxes. This could be done in a few months time, when the *Sun* has sufficiently withdrawn from the field.

Of the stars within two degrees of the *Sun* at the time of the eclipse, there is only one for which parallaxes have been published, viz. *β Virginis*. The values available are: —

Observer	Observatory	Method	Parallax		Reference
Chase	Yale	Heliometer	$0''.11$	$\pm 0''.047$	Trans. Yale Obs. II, 392
Schlesinger	Allegheny	Photographic	0 .096	±0 .006	Pub. Allegheny Obs. IV, 102
Mitchell	McCormick	Photographic	0 .096	±0 .008	*A. J.* 33, 79
Adams	Mt. Wilson	Spectroscopic	0 .087		*Ap. J.* 53, 13

From these we may adopt $0''.100$ as the absolute parallax. Denoting by p_α and p_δ the displacements in R. A. (on a great circle) and Dec. respectively we have, with the adopted parallax

$$p_\alpha = -0''.006\ \mathrm{X}\ -0''.100\ \mathrm{Y}$$
$$p_\delta = +0\ .004\ \mathrm{X}\ +0\ .100\ \mathrm{Z},$$

where X, Y and Z are the *Sun's* coördinates on the

date of observation. The maximum displacement occurs on or about June 18, and is $-0''.093$ in R. A. and $+0''.010$ in Declination. The displacements at the time of the eclipse are $+0''.002$ and $-0''.002$ respectively.

Parallaxes of two other stars that may be on the eclipse plates have been determined at the Dearborn Observatory, and were kindly communicated by DIRECTOR FOX. They are:

B. D. $-0°2510$	$0''.079$	$\pm 0''.016$	5 comp. stars used
B. D. $-0\ 2510$	$0\ .063$	$\pm 0\ .017$	3 comp. stars used
B. D. $-0\ 2512$	$0\ .052$	$\pm 0\ .021$	5 comp. stars used

The P. E's. are rather larger than usual, but we may adopt $0''.08$ and $0''.06$ as the absolute parallaxes. We shall then have for the parallactic displacements, neglecting terms not greater than $0''.003$

B. D. $-0°2510$	$p_x = -0''.08$ Y	$p_\delta = +0''.08$ Z
B. D. $-0\ 2512$	$p_x = -0\ .06$ Y	$p_\delta = +0\ .06$ Z

In deducing the equations above for p_x and p_δ I have made use of the fact that any parallax factor f may be thrown into the general form

$$f = a\,X + b\,Y + c\,Z$$

in which a, b and c are constants for any particular star, and X, Y and Z the *Sun's* coördinates, of which the natural values are given in the national ephemerides for each noon and midnight. In particular, using λ and β for longitude and latitude respectively, and ϵ for the obliquity of the ecliptic

$$f_x = -X \sin\alpha + Y \cos\alpha$$
$$f_\delta = -X \cos\alpha \sin\delta - Y \sin\alpha \sin\delta + Z \cos\delta$$
$$f_\lambda = -X \sin\lambda + Y \cos\lambda \sec\epsilon$$
$$f_\beta = -X \cos\lambda \sin\beta - Y \sin\lambda \sin\beta \sec\epsilon$$

If SCHLESINGER'S* or PITMAN'S† tables are not available, or if more decimals are required, the above expressions, with CRELLE'S or COTSWORTH'S multiplication tables, will be found as convenient as any hitherto proposed.

**Pub. Allegheny Obs.* Vol. III, 161.
†*A. J.*, No. 681.

CORRECTION TO NEWCOMB'S *FUNDAMENTAL CATALOGUE*,

BY R. H. TUCKER.

The star No. 1186 in *Scuti* at $18^h\ 23^m$, $-14°\ 37'$, has an evident error in the proper-motion derived and applied in right ascension. This should apparently read $0^s.021$, in place of $0^s.210$.

The star is not in the list of the *American Ephemeris*, but its right ascension at this date would be $0^s.17$ too large.

Lick Observatory,
Dec. 18, 1922.

NOTE

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BENJAMIN BOSS, *Editor*

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ON THE APPLICATION OF DELAUNAY'S LUNAR THEORY TO THE EIGHTH SATELLITE OF *JUPITER*.

BY ERNEST W. BROWN.

The theory of DELAUNAY, originally constructed to give the position of the *Moon*, is entirely literal and should therefore be applicable to any satellite. The expressions which he obtains for the coördinates are sums of harmonic terms and the coefficient of any term is expanded in powers of certain parameters whose values are to be obtained from observation. The expansions are taken sufficiently far so that, in the case of the *Moon*, no coefficient is in doubt by so much as 1″. In the case of *Jupiter VIII*, the numerical values of the parameters are so much larger that the doubt is of the order of 1′, due to slow convergence. The main object of this paper is to examine whether, by changing the forms of the series or by estimation of their remainders, we can obtain a better approximation to the position of *Jupiter VIII*, so far as the perturbations by the *Sun* are concerned.

Denoting by n', a', e' the mean motion, mean distance and eccentricity of the planet, by n, a, e the corresponding elements of the satellite, and by i the angle between the planes of their orbits, the approximate numerical values of the parameters are

	$m = n'/n$	e	e'	$\sin \frac{1}{2} i$	a/a'
Moon	.075	.055	.017	.045	.0025
Jup. VIII	−.017	.4	.048	.25	.03

DELAUNAY has taken his theory to the seventh order of small quantities on the approximate basis of treating .1 as a small quantity of the first order. The slowest part of the convergence in the case of *Jupiter VIII* would therefore seem to be that along powers of e. But the numerical coefficients along powers of m increase so rapidly in many cases that the difficulty here is even greater; for many coefficients the rate of convergence appears to be similar to that of a geometric series with ratio $4m$. For the *Moon*, this ratio is .3, for *Jupiter VIII* it rises to .7 and sometimes higher, so that the series are defective for accurate numerical computation.

This similarity to a geometric series is noticeable in so many coefficients that it suggests we should try to estimate remainders on this basis. The data at our disposal are as follows. We have from DELAUNAY, the value of any coefficient C expressed in the form $C_p = \Sigma\, a_i m^i$ as far as $i = p$, suppose. We also have from my theory the numerical value of C to a high degree of accuracy for $m = .075$ . . From these we obtain $C - C_p$ when $m = .075$ . . The assumption is that the remainder is of the form $a_p km/(1 - km)$, so that k may be found. The complete coefficient can then be written

$$C = a_0 + a_1 m + \ldots + a_p\, km/(1 - km),$$

in which any value of m may be inserted. When $k = 4$, the ratio $km/(1 - km)$ for the *Moon* is about .4 and it is nearly the same for *Jupiter VIII*.

The assumption may be used by substituting the results in the equations of motion, that is, by using them as a first approximation to the coördinates and then finding the corrections required — a procedure which should be less laborious than calculation *ab initio*. We have, of course, to assume that the results used are correct, that is, that DELAUNAY's literal values and my numerical values are not in error to such an extent that no confidence can be placed in the remainders. In certain cases, notably in the terms with factor e^2, it is known that the higher powers of m of DELAUNAY's series have wrong numerical coefficients (E. W. BROWN, *M. N.*, vol. LVII, p. 336; H. ANDOYER, *Bull. Astr.* vol. XVIII). It has seemed worth while to test the assumption in one case where it can be completed, namely, for that part of the mean motion of the apse which depends only on m.

For this test we have the literal value in powers of $m_1 = n'/(n-n')$ as far as m_1^{11} given by G. W. HILL (*Annals of Math.*, vol. IX, p. 40), the complete numerical value with $m_1 = .08084\ 89338$, also by HILL (*Motion of the Perigee*, Cambridge, 1877, p. 40. This paper is reprinted in *Acta Math.*, vol. VIII. It is referred to below as "*Perigee*" with the paging of the former reference). The complete numerical value with $m = -1/6$ or $m_1 = -1/7$ is obtained in the Appendix below. The data from these various sources are shown in the following table where the mean motion of the apse is expressed in the form $n\,\Sigma a_i m^i$.

i	$\log a_i$	$\log a_{i+1}/a_i$	$a_i(.080\quad)^i$	$a_i(-7)^{-i}$
2	9.8750 613	.8678	+.0019 0211 25	+.0153 0612
3	0.7428 233	.3698	+ 29 2311 71	− 161 2609
4	1.1126 364	.5065	+ 5 5377 53	+ 53 9814
5	1.6191 351	.4780	+ 1 4371 65	− 24 7510
6	2.0971 263	.5451	+ 3192 79	+ 10 6301
7	2.6421 868	.5871	+ 990 62	− 5 3272
8	3.2293 137	.6218	+ 309 53	+ 2 9412
9	3.8511 635	.6383	+ 104 77	− 1 7591
10	4.4894 959	.6453	+ 36 83	+ 1 0927
11	5.1348 032		+ 13 16	− 6898
Sum $= C_p$			+.0085 7249 87	+.0027 9156
Complete C			+.0085 7257 30	+.0028 1783
$C - C_p$			+ 7 43	+ 2627

Following the procedure outlined we put

$$\frac{743}{1316} = \frac{km_1}{1-km_1} \text{ with } m_1 = .08085, \text{ giving } k = 4.463.$$

The estimated remainder with $m_1 = -1/7$ is then

$$+6898\,k/(7+k) = 2685,$$

in units of the eighth place of decimals. As the actual difference is 2627, the error of the estimate is only 58, or rather more than two per cent of the estimate. It is interesting to notice that the value of k obtained in this way is almost exactly that which would be deduced from the third column, which gives the logarithms of the ratios of successive coefficients.

This partly empirical method gives a good result in the case of one difficult series but it is doubtful how much dependence should be placed on it for obtaining all the coefficients of the harmonic terms. It is, in general, only useful when more than two or three powers of m are given, and is therefore not dependable for the higher powers of the remaining parameters. It may be stated here that sometimes the terms depending on the higher powers of the other parameters are larger in the case of *Jupiter VIII* than those depending on the lower powers: for example, in the case of the mean motion of the perijove, the remaining terms (estimated as above) appear to be about twice the magnitude of those just calculated and of the opposite sign, so that the motion is in the opposite direction to that of the satellite with a period of about 800 years.

A theoretical basis for the procedure adopted above can be furnished in the cases of certain terms, and notably in that of the "evection," the coefficient of which enters into those of many other periodic terms. I have shown elsewhere (*Amer. Jour. Math.*, vol. XVII, p. 356) that the principal divisors, due to integration of the equations of motion, of a term with period $2\pi/pn$ are contained in the expression

$$p^2[p^2-(1-\varpi_1)^2],$$

where $n\varpi_1$ is the mean motion of the apse, and has the approximate expression

$$\left(\frac{3}{4}m^2+\frac{225}{32}m^3+\ldots\right)n = \left(\frac{3}{4}m_1^2+\frac{177}{32}m_1^3+\ldots\right)n.$$

For the evection, $p = 1-2m+\varpi_1$, so that the expression is

$$-4(1-2m-\varpi_1)^2(1-m)(m+\varpi_1).$$

The expansion of the inverse of a divisor of this kind indicates how large numerical coefficients along powers of m may arise. Incidentally, this divisor, which in

the case of the *Moon* is $-.17$, becomes $+1.1$ for *Jupiter VIII*. Hence it is scarcely a "small" divisor in the latter case; but if we expanded its inverse in powers of m, the first term would be $-1/4m = +1.5$ which is a poor approximation to $1/1.1 = .7$. A divisor $1 - 4m - \dots$ was actually found in the case of the parallactic inequality (E. W. Brown, *M. N.*, vol. LII, p. 77).

Hill, in the papers referred to above, pointed out the improved convergence which comes with the use of the parameter m_1 instead of m. It is doubtful, however, if the improvement gained is worth the labor of transforming all Delaunay's results. In any case most of it is really included in the above method of estimation, as is obvious theoretically.

Most of the trouble will disappear if we can avoid the expansion of divisors due to integration. Any method but that of using numerical values from the outset appears to introduce complications far too great to be useful. The objection to a numerical theory of *Jupiter VIII* arises from the fact that we do not know the constants of its orbit accurately and probable changes in the constants will necessitate much recalculation. I hope to publish later a method by which these difficulties are solved or avoided. A preliminary calculation shows that the chief assistance which can be furnished by estimates from Delaunay is the knowledge of the orders of magnitude of the various terms. We thus know in advance whether our early approximations are good or poor. We also know what terms may be neglected and what should be retained. Valuable information is already gained by knowing that the mean motion of the perijove is so small. The first approximation to the "variation" and "evection" gives their values within ten per cent.

APPENDIX

Calculation of the part of the perijove of *Jupiter VIII* which depends only on the mean motions of the satellite and of *Jupiter*.

The material for this calculation is contained in "Researches in the Lunar Theory" by G. W. Hill (*Amer. Jour. Math.*, vol. I, pp. 1-26, 129-147) and in the paper "Perigee" referred to above. All these papers are found in his collected works, but the page references below are those of the references given.

As the formulae in "Perigee" were somewhat troublesome to apply in the forms given, I translate them to real quantities. Hill's u, s, ζ, D, m, κ are defined as follows:

$$\tau = nt + \epsilon - n't - \epsilon', \qquad \zeta = \exp.\, \tau\sqrt{-1},$$
$$D = \zeta \frac{d}{d\zeta} = -\sqrt{-1}\,\frac{d}{d\tau},$$

$$u = (x + y\sqrt{-1})\zeta, \qquad s = (x - y\sqrt{-1})\zeta^{-1},$$
$$r^2 = x^2 + y^2,$$

$$m = n' / (n - n') = m_1, \qquad \kappa = (1 + m_1)^2 a_2, \qquad a^3 n^2 = \mu.$$

Use a prime mark to define derivatives with respect to τ and put

$$V^2 = 2\Omega - 2C = -Du - Ds = (x' - y)^2 + (y' + x)^2,$$
$$2h = sDu - uDs = 2x(y' + x) - 2y\,(x' - y),$$
$$2V' = Du - Ds = 2(x' - y)\sin\tau + 2\,(y' + x)\cos\tau,$$
$$\xi' = x(x' - y) - y(y' + x),$$
$$\eta' = x(y' + x) + y\,(x' - y).$$

Then (Perigee, p. 8)

$$\Delta = \left(\frac{\kappa}{r^3} - \frac{3}{2}m_1^2\right)h - \frac{3}{2}m_1^2\,(\xi'\sin 2\tau + \eta'\cos 2\tau) - m_1 V^2,$$

$$\Theta = \frac{\kappa}{r^3} - 3\,\frac{h^2}{V^2}\,\frac{\kappa}{r^3} - 3m_1^2\,\frac{V'^2}{V^2} + 3\,\frac{\Delta^2}{V^4} + m_1^2.$$

The differential equation to be solved is (Perigee, p. 13)

$$-w'' = D^2 w = \Theta\, w$$
$$= (\Theta_0 + 2\,\Theta_1\cos 2\tau + 2\,\Theta_2\cos 4\tau + \dots)w.$$

The solution is $w = \Sigma_i b_i\, \zeta^{c+2i}$ giving,

$$(c + 2j)^2\, b_j - \Sigma_i\, \Theta_{j-i}\, b_i = 0 \qquad (a)$$

Where i, j receive all positive and negative values and $\Theta_{-i} = \Theta_i$. The unknowns are c and the b_i, and the motion of the perigee is given by

$$n\left(1 - \frac{c}{1 + m_1}\right).$$

The solution is best carried out by finding an approximate value for c and substituting it everywhere in the equations (a) except in the term $(c^2 - \Theta_0)\, b_0$ in the equation given by $j = 0$; the b_j are then eliminated and a value for $c^2 - \Theta_0$ is found, whence c is deduced. It is easily seen that, for the degree of accuracy needed here, we can confine our attention to the five equations for $j = 2,\ 1,\ 0,\ -1,\ -2$, retaining only the five unknowns b_{-1}, b_1, b_{-2}, b_2, b_0 and eliminating them in this order (Perigee p. 27). The approximate value of c

was obtained from the literal series given above and only one approximation was found necessary, although two were carried out for the sake of testing the work. The principal numerical steps will now be given.

The values of x, y can be obtained to 8 places of decimals from the series in powers of $\mathfrak{M}$ (Researches, p. 113) where $\mathfrak{M} = -3/22$ when $n'/n = 1/6$, as follows:

$$x = \{1 - .0172\,5180 \cos 2\tau + .0000\,2056 \cos 4\tau + .0000\,0027 \cos 6\tau\}\, a_0$$

$$y = \{+ .0221\,3626 \sin 2\tau + .0000\,2315 \sin 4\tau + .0000\,0021 \sin 6\tau\}\, a_0$$

and (p. 115)

$$a_0 = .9957\,0636a, \qquad \kappa = .7142\,3925\, a_0^3$$

From these we deduce for the five special values 0, 180, 90, 60, 120 of 2τ, the following results:—

2τ	r^2/a_0^2	κ/r^3	V^2/a_0^2
0	+.9658 3556	+.7810 7539	+1.0562 4105
180	1.0348 1191	.7069 7094	.9457 3764
90	1.0001 6225	.7137 2354	.9999 1936
60	.9831 8034	.7634 1988	1.0278 0087
120	1.0176 8247	.7249 2676	.9725 7264

2τ	h/a_0^2	ξ'/a_0^2	η'/a_0^2
0	+1.0100 2731	0	+1.0100 2731
180	.9892 8708	0	.9892 8708
90	.9995 9551	−.0103 6514	1.0001 3705
60	1.0017 9567	−.0094 1852	1.0051 9863
120	.9914 2629	−.0085 0899	.9948 3551

2τ	Δ	Θ	i	Θ_i
0	+.8809 9076	+.1781 0682	0	+.7064 6753
180	.8345 0261	.9422 6144	1	−.1159 3782
90	.8559 8575	.7027 5139	2	+.0018 5781
60	.8680 1545	.5888 7352	3	−.0001 0148
120	.8448 1963	.8203 4345	4	+.0000 0124

An estimate of the value of Θ_5 (-10 in the eighth place) has been subtracted from Θ_1: the resulting change in c is only one unit in the eighth place.

Thence $\qquad c = .8547\,2756$, and

Motion of perijove $= +.0028\,1783n$.

Yale University,
1922.

A COMPARISON OF CLOCK CORRECTIONS DETERMINED WITH LARGE INSTRUMENTS,

By H. R. MORGAN.

(Communicated by Captain W. D. MacDougall, U. S. Navy, Superintendent, U. S. Naval Observatory.)

Recent inter-comparisons of wireless time signals show rather large variations in the time sent from one observatory as compared with that sent from others; and suggestions have been made that such variations may be due to the observations. To see how far this might be the case with definitive clock corrections used in reductions of work on large fixed instruments, the following comparison was made of the clock corrections taken within a few hours of each other on the same night with the 9-inch transit circle and the 6-inch transit circle of the U. S. Naval Observatory. These instruments are permanently mounted in identical large buildings. With the variable screen system on the 9-inch all stars were observed as of 9th mag., and the transits over the ten fixed threads were recorded by key and chronograph. With the screens on the 6-inch all stars were observed as between the 6th and 9th mag's., and the hand-driven travelling threads sent twenty automatic signals to the chronograph. Reversing prisms were used on both instruments. The personal equations of the ten observers, observing under these conditions, were determined from measures on the personal equation machines. The 6-inch was reversed every two or three weeks, and the 9-inch three or four times a year; the object glass and eye end of the 6-inch were interchanged in June 1917; the micrometers were off at different times; a printing chronograph replaced the writing chronograph with the 9-inch April 1, 1914; and other adjustments were made which might affect the continuity of clock corrections.

The observing programs were similar and the same system of star places, and stars of the same general declination, between +30° and −20°, were used. Azimuths were reduced using meridian marks, and levels using mercury basins. The same clock was used on both chronographs at any time, and the three Riefler clocks, under constant temperature and pressure

Differences in Clock Corrections, (9-inch − 6-inch)

Year	No.	Clamp 9″	Clamp 6″	ΔT 9″−6″	Clamp Diff. 6″, (W−E)	ΔT 9″−½(W+E)6″	Clamp Diff 9″, (W−E)	ΔT Corr'd 9″−6″
				s	s	s	s	s
1913.85	1	E	E I	−0.017				+0.027
.88	12		W	+ 16	−0.063			− 24
.93	14		E	− 1	− 17			+ 13
.97	12		W	+ 72	− 73			+ 2
1914.03	8		E	− 9	− 81			+ 35
.06	10	E	W	+ 66	− 75	E_{10} +0.025		− 1
.11	4	W	E	+ 39				+ 23
.13	3		W	+ 134	− 95			+ 1
.16	3		E	+ 39	− 95			+ 23
.17	4		W	+ 146	− 107			+ 16
.18	2		E	+ 4	− 142			− 12
.19	6		W	+ 138	− 131			+ 8
.22	1		E	+ 28	− 110			+ 12
.26	6		W	+ 107	− 79			− 23
.30	6		E	+ 26	− 81			+ 10
.33	1	W	W	+ 96		$W_{[illegible]}$ +0.078	+0.053	− 34
.37	8	E	W	+ 35				− 35
.43	8		E	− 33	− 68			+ 11
.50	8		W	+ 113	− 116			+ 13
.55	4		E	+ 18	− 95	E_{28} +0.027	+0.051	+ 62
.65	10		W	+ 78	− 60			+ 8
.70	4		E	− 25	− 103			+ 19
.76	8		W	+ 71	− 99			+ 1
.81	9	E	E	− 105	− 179	E_{31} +0.001		− 61
.89	9	W	E	+ 18	...			+ 2
.97	7		W	+ 163	− 145			+ 33
1915.01	7		E	− 12	− 175			− 28
.04	4		W	+ 162	− 174			+ 32
.07	4	W	E	+ 28	− 134	W_{41} +0.080	+0.079	+ 12
.26	7	E	E	− 52	...		...	− 8
.30	6	E	W	+ 96	− 148	E_{13} +0.021	+0.059	+ 26
.44	2	W	E	− 8	...			− 24
.46	3		W	+ 136	− 144			+ 6
.48	4		E	+ 12	− 124			− 4
.52	7		W	+ 135	− 123			+ 5
.56	5		E	+ 18	− 117	W_{29} +0.073	+0.052	+ 2
.69	4		W	+ 90	− 72		...	− 40
.72	16		E	− 29	− 119			− 15
.79	17	W	W	+ 121	− 150	W_{37} +0.015		− 9
.84	6	E	E	− 38				+ 6
.87	8		W	+ 33	− 71	E_{14} −0.005	+0.050	− 37
.90	6		E	− 123				− 21
.96	12		W	+ 8	− 131			− 4
1916.04	12	E	E	− 121	− 129	$E_{[illegible]}$ 0.058		− 19
.10	3	W	E	− 62				− 20
.15	9	W	W	+ 96	− 158	$W_{[illegible]}$ +0.028	+0.086	+ 21
.44	3	E	E	− 82				+ 20
.47	4		W	+ 35	− 117			+ 23
.53	5		E	− 95	− 130	...	...	+ 7

Year	N	Clamp 9″	Clamp 6″	ΔT 9″−6″	Clamp Diff 6″, (W−E)	ΔT 9″−½(W+E)6″		Clamp Diff 9″, (W−E)	ΔT Corr'd 9″−6″
				s	s		s	s	s
.58	4	E	W	−36		E_{10}	0.034	+0.062	−18
.68	1	W	W	+52				..	−20
.72	2		E	58	−110			.	−16
.78	3	W	W	+76	−131	W_9	+0.001	+0.038	+4
.81	2	E	W	+33				..	+21
.85	1		E	−93	−126			..	+9
.89	1		W	+1	−97		.	..	−8
.93	1		E	−88			.	.	+14
.99	2	E	W	+8	.	E_{11}	−0.011	+0.045	−4
1917.04	3	W	E	−83			...	..	−14
.18	2		W	+63	−116		.	..	−9
.21	1		E	−62	−125			...	−20
.26	8	W	W	+81	−116	W_{17}	+0.008	+0.049	+12
.33	3	E	E	−67				...	+35
.39	5		W I	−5	−62	E_8	−0.043	+0.054	−17
.47	1	E	W II	−57			.	..	−74
1918.09	5	W	W	+119			.	..	+42
.16	6		E	−36	−155			.	+11
.22	5		W	+78	−111			...	+1
.32	3		E	−28	−0.[illegible]46		.	.. ..	+19
1918.47	1	W	W II	+0.068				..	−0.009

served as standards at different times. The clock beats were distributed to the chronographs, before November 20, 1915, from points of a 7-point relay operated by the clock circuit, and after that date by two systems of secondary relays operated by two primary relays which replaced the 7-point. These new relays were variously adjusted to suit the convenience of the several chronographs, and this change of relays introduced a discontinuity of $0^s.014$ in the relative clock corrections of the two instruments at that time.

During the five years, 1913.5–1918.5 there were 397 clock corrections, determined nearly simultaneously on the two instruments, which, when corrected for personal equation and difference in longitude, were run together with definitive rates, and their differences taken. The differences in the clock corrections from the two instruments vary as much as $0^s.2$, or more, in short intervals, but it was at once seen that this variation was due to the clamp positions of the instruments, and group means were formed, therefore, according to clamps as given in column 1 of the table. From these means were formed, first, the differences given in column 5, which represent the changes, or discontinuities, in the clock corrections produced by reversal of the 6-inch transit circle. The means in column 6 are freed from this 6-inch clamp term and their differences, given in column 7, represent the changes, or discontinuities in the clock corrections produced by reversal of the 9-inch transit circles. These clamp terms are for the equatorial region only, those at the zenith are different. When corrected for clamp terms of both instruments, the mean of the differences in the clock corrections was $+0^s.043$ before November 20, 1915, and $-0^s.015$ after that; and the residuals from these means are given in the last column of the table. Of the 397 individual residuals only four are as large as $0^s.1$.

It appears that these instruments held closely together for the five years, the noticeable features of the comparison being the change with change of relays, and especially the clamp terms, which must be taken account of in absolute time, or longitude work. Now this latter cannot be done when preliminary reductions have to be made for a time signal sent a few hours after the observations have been made. While from previous work a mean value of the clamp term might be used, yet from an inspection of the quantities in the fifth column of the table it is seen that the change with clamp itself varies more than $0^s.1$. Hence changes of this size are liable to occur in the time signals as sent from preliminary clock corrections determined with these instruments, as will be shown also in a later paper, and it would seem that a part, at least, of the discordances found in the comparisons of signals from different observatories may be due to the

observations. However, the above comparison shows that by using two instruments it is possible by definitive reductions to find later the proper corrections to signals as sent, and to reduce their uncertainties to 0s.02 or 0s.03 as far as the observations go. Such procedure may be followed in longitude work, and the fixed instruments of observatories used for such work.

SECOND NOTE ON TAYLOR'S COMET, *1916 I.*

By H. M. JEFFERS.

In *Astronomical Journal*, No. 791, there was a note on the return of this comet, with a short ephemeris for the period during which it was visible. There is no record of its having been found at this time.

This comet is again in position for observation in the early part of 1923. While it will be faint, it should be within the range of a large telescope. It is very desirable that some positions of the comet be obtained at this time, if the motion is to be followed. A preliminary investigation has shown that during the present revolution it will pass quite close to *Jupiter*. It will be at aphelion in August, 1925. For a year and a half around this time the distance comet-*Jupiter* will be less than one astronomical unit, and for three months it will be under three tenths of an astronomical unit.

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT

	α (1920.0)	δ (1920.0)	log r	log Δ
	h m	° ′		
1923 Jan. 23	15 18.4	−2 35	0.4092	0.4194
31	26.5	2 29		
Feb. 8	33.4	2 16	0.4251	0.3998
16	39.0	1 55		
24	43.1	1 28	0.4405	0.3787
Mar. 4	45.7	0 54		
12	46.7	−0 16	0.4550	0.3584
20	46.0	+0 26		
28	43.7	1 10	0.4687	0.3443
Apr. 5	39.8	1 53		
13	34.7	2 33	0.4819	0.3327
21	28.3	3 7		
29	21.5	3 35	0.4945	0.3364
May 7	14.2	3 55		
15	7.2	4 0	0.5061	0.3532
23	15 0.9	3 56		
31	14 55.0	+3 42	0.5178	0.3824

The elements upon which the ephemeris is based are given in *Lick Observatory Bulletin* 334. They are those of component (B), based upon a least squares solution using a large number of observations. The perturbations since 1916, January 21, have not been applied. Since during the past revolution the comet did not pass near *Jupiter* we may expect the perturbations to be small.

The following table gives the corrections to be applied to the above ephemeris, on the two assumptions that the perihelion passage occurs 8 days before, and 8 days after, 1922 June 13.5, the undisturbed time.

	T = 1922 June 5.5		T = 1922 June 21.5	
	$\Delta\alpha$	$\Delta\delta$	$\Delta\alpha$	$\Delta\delta$
1923	m	′	m	′
Jan. 23.5	+1.6	−28	−1.9	+32
Mar. 28.5	+5.3	−42	−5.8	+47
May 31.5	+5.8	−37	−6.4	+42

The magnitude will be 17.5 on April 13, 1923, according to the estimate of brightness made by PROFESSOR BARNARD at the last observation in 1916. Estimates of brightness made near perihelion in 1916 indicate a magnitude of 15 for the date above.

Iowa State University,
December 15, 1922.

THE PARALLAX OF *B. D.* 39° (4694) USING TWO SETS OF COMPARISON STARS.

By LAURA E. HILL.

The field of *B. D.* 39° (4694), magnitude 8.6, is rich in stars. Hence it offers an excellent opportunity for testing the effect of the distance of comparison stars on the determined parallax. Two sets of comparison stars of four each were chosen, situated as shown on Diagram 1. The mean magnitude of the near stars is 9.2 at the average distance from the parallax star of 317″. The mean magnitude of the distant stars used is 9.0, at an average distance of 1288″. Sixteen plates, representing seven different epochs extending

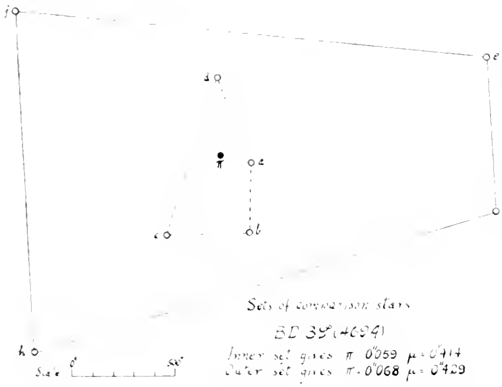

Diagram I

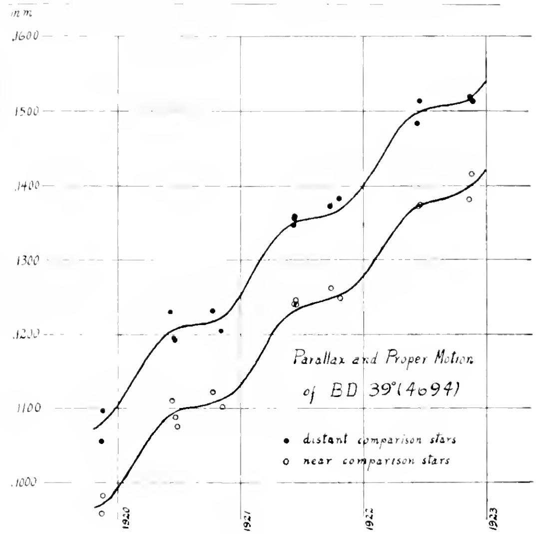

Diagram II

from November 11, 1919 to November 22, 1922, were measured. The results obtained were as follows:

	Relative Parallax	Relative Proper-Motion in R. A.
Near Comp. Stars	+0″.059 ±0″.008	+0″.411 ±0″.007
Distant Comp. Stars	+0 .068 ±0 .009	+0 .429 ±0 .008

The similarity of the results is further shown by Diagram II. The dots and circles represent observed values; the curves are computed from the values given above.

The two sets of comparison stars, radically different in distribution, are seen to give quite accordant values.

Dearborn Observatory,
9, January, 1923.

OCCULTATION OF *VENUS*,

BY HAROLD L. ALDEN AND J. W. BLINCOE

The recent occultation of *Venus* was observed with the twenty-six inch refractor and the five inch finder of the Leander McCormick Observatory. The seeing was poor — one to two on a scale of five. Consequently the times of contact of the north cusp at immersion and the south cusp at emersion are subject to considerable uncertainty. The chronometer correction was determined by comparison with the wireless signals from Arlington at noon on January 12 and 15.

The observed Greenwich Mean Times of the various phenomena are as follows:

Immersion		ALDEN (26 inch)	BLINCOE (5 inch)
		h m s	m s
Contact south cusp	Jan. 12	23 25 13	25 13
north cusp		26 33(?)	26 12(?)
limb		26 51.5	26 52
Emersion			
Contact north cusp	Jan. 13	0 25 37	25 38
south cusp		27 03(?)	. . . .
limb		27 21	. . . .

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OBSERVATIONS OF THE SATELLITES OF *SATURN*, 1914-15.

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY

By ASAPH HALL.

[Communicated by CAPTAIN W. D. MACDOUGALL, U. S. Navy, Superintendent of U. S. Naval Observatory.]

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
				Mimas-Tethys				
	h m s	°	h m s	"				
1914 Oct. 2	15 30 18	62.64	15 31 11	21.63	2 , 2	2	367b, Brt.	Moonlight.
Nov. 23	12 13 16	265.99	12 13 24	80.11	2 , 2	2	367b, Red	
23	12 33 10	264.41	12 33 25	81.20	2 , 2	2	367b, Red	
Dec. 12	10 11 16	259.68	10 9 7	80.58	2 , 2	2	367b, Red	Haze. *Mimas* went out.
15	16 9 30	54.74	16 8 40	12.08	2 , 2	2	388, Red	
15	16 24 38	52.07	16 23 11	10.63	2 , 2	2	388, Red	
27	10 48 18	266.28	10 49 1	81.45	2 , 2	2	367b, Red	
27	11 7 0	264.81	11 8 51	81.63	2 , 2	2	367b, Red	
1915 Jan. 4	11 29 18	122.73	11 29 26	34.76	2 , 2	2	388, Brt.	
4	11 47 33	119.62	11 47 51	35.56	2 , 2	2	388, Brt.	
4	12 55 8	109.21	12 55 16	38.51	2 , 2	2	367b, Red	
4	13 16 56	107.14	13 17 18	38.51	2 , 2	2	367b, Brt.	
13	9 27 46	270.03	9 29 26	79.00	2 , 2	2	367b, Brt.	
13	9 44 18	268.36	9 43 10	79.77	2 , 2	2	367b, Brt.	
29	9 59 32	91.92	9 49 36	17.08	2 , 2	3 4	367b, Red	
29	10 43 2	95.09	10 13 15	18.44	2 , 2	3 4	367b, Red	Haze. Clouds
Feb. 17	8 50 42	100.31	8 42 47	22.26	2 , 2	2	367b, Red	*Mimas* very faint. Haze.
Mar. 13	8 4 17	145.12	8 1 59	20.54	2 , 2	2	367b, Red	
13	8 31 6	138.40	8 24 18	20.83	2 , 2	2	367b, Red	
				Mimas-Rhea				
1914 Nov. 23	13 41 49	35.42	13 43 19	36.67	2 , 2	2	367b, Brt.	
23	13 57 26	35.36	13 56 42	36.30	2 , 2	2	367b, Brt.	
Dec. 15	15 21 32	82.04	15 26 14	119.99	2 , 2	2	367b, Red	
15	15 43 46	81.03	15 46 20	119.98	2 , 2	2	367b, Red	
18	11 35 26	195.13	11 33 53	40.22	2 , 2	2	388, Brt.	First half with power 367b.

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
			Mimas-Rhea (Continued)					
	h m s	°	h m s	″				
1914 Dec. 18	11 53 7	192.84	11 50 52	38.88	2 , 2	2	388, Brt.	
1915 Jan. 1	9 19 25	284.31	9 49 39	50.87	2 , 2	2	367b, Red	
1	10 11 51	282.40	10 12 48	50.66	2 , 2	2	367b, Red	
1	12 15 30	284.01	12 45 41	55.41	2 , 2	2	367b, Red	
1	12 33 34	283.88	12 34 32	56.72	2 , 2	2	367b, Red	
1	14 11 34	282.31	14 17 41	67.14	2 , 2	2	367b, Red	
1	14 37 4	281.67	14 37 54	69.48	2 , 2	2	367b, Red	*Mimas* very faint.
5	8 30 36	219.53	8 28 37	47.84	2 , 2	2	388, Brt.	*Mimas* faint. Stopped [by haze.
13	10 1 5	275.67	10 2 38	109.44	2 , 2	2	367b, Brt.	
14	9 42 8	246.64	9 22 54	97.46	4 , 2	2	367b, Brt.	Clouded.
15	8 24 28	148.36	8 18 38	41.18	2 , 2	3	367b, Red	*Mimas* very faint.
Mar. 12	8 43 17	40.38	8 12 48	48.06	2 , 2	3	367b, Red	
12	8 39 34	38.20	8 38 34	47.94	2 , 2	3	367b, Red	
13	9 5 4	277.24	9 8 4	54.06	2 , 2	2	367b, Red	
13	9 38 42	277.54	9 38 54	56.45	2 , 2	2	367b, Red	
			Enceladus-Tethys					
1914 Sept. 26	11 18 19	109.18	11 18 8	57.82	2 , 2	3	388, Brt.	
28	13 39 6	98.40	13 39 59	6.71	2 , 2	2 3	388, Brt.	
28	14 1 56	102.15	14 3 12	6.50	2 , 2	2 3	388, Brt.	
Oct. 1	14 51 9	260.93	14 52 6	78.45	2 , 2	2-3	367b, Brt.	
1	15 23 33	258.68	15 23 58	77.36	2 , 2	2-3	367b, Brt.	
2	11 10 50	62.62	11 9 38	41.19	4 , 4	2	367b, Brt.	Moonlight.
18	15 2 7	269.44	15 3 33	8.83	2 , 2	3	367b, Brt.	
18	15 18 14	267.60	15 18 24	8.80	2 , 2	3	367b, Brt.	
19	15 5 22	103.43	15 8 26	42.93	2 , 2	2	388, Brt.	
19	15 26 39	104.74	15 26 30	44.22	2 , 2	2	388, Brt.	
27	12 58 2	301.87	12 56 50	34.75	2 , 2	3	388, Brt.	
27	13 39 21	298.28	13 38 20	34.03	2 , 2	3	388, Red	
30	14 17 36	142.77	14 47 54	40.55	2 , 2	3	388, Brt.	
30	15 1 56	139.27	15 3 10	42.10	2 , 2	3	388, Brt.	
31	14 3 48	283.37	14 3 30	67.50	2 , 2	2	388, Brt.	
31	14 17 0	282.23	14 17 48	69.16	2 , 2	2	388, Brt.	
Nov. 2	12 24 31	272.72	12 23 32	8.80	2 , 2	3	388, Brt.	
2	13 2 32	275.29	13 4 42	8.09	2 , 2	3	367b, Brt.	*Enceladus* v. ft. Haze.
5	12 18 3	81.45	12 19 22	85.31	2 , 2	2	388, Red	
5	12 39 12	82.52	12 40 34	84.83	2 , 2	2	388, Red	Haze.
6	11 22 31	228.19	11 18 58	33.88	2 , 2	2	388, Brt.	
6	11 43 10	225.14	11 43 56	34.65	2 , 2	2	388, Brt.	Moonlight.
9	13 51 22	72.62	13 57 14	78.46	2 , 2	3	367b, Brt.	
9	14 10 56	71.10	14 10 18	78.32	2 , 2	3	367b, Brt.	
11	11 42 32	1.73	11 42 1	25.49	2 , 2	2	388, Brt.	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
			Enceladus-Tethys (Continued)					
	h m s	°	h m s	″				
1914 Nov. 11	12 6 30	354.41	12 6 20	25.08	2 . 2	2	388, Brt.	
16	12 18 53	99.21	12 19 4	48.45	2 . 2	3	388, Brt.	
16	12 33 49	98.02	12 34 48	18.75	2 . 2	3	388 Brt.	
17	13 28 8	291.41	13 28 41	6.11	2 . 2	2	388 Brt.	
17	13 40 56	295.32	13 39 50	5.72	2 . 2	2	388, Brt.	Haze.
21	11 52 26	75.63	11 51 29	54.65	2 2	2	367b, Brt.	
21	12 20 12	73.68	12 20 18	52.98	2 . 2	2	367b, Brt.	
22	12 23 58	78.84	12 24 42	10.46	2 . 2	3	388, Brt.	
22	12 42 5	78.61	12 40 6	10.25	2 . 2	3	367b, Brt.	
23	11 30 42	296.61	11 32 24	32.73	2 . 2	2 3	388 Brt.	
23	11 49 6	294.24	11 48 35	34.13	2 . 2	2 3	388, Brt.	
Dec. 16	14 6 21	114.20	14 4 30	36.22	2 . 2	3	388, Brt.	
16	14 23 27	112.38	14 23 54	37.27	2 . 2	3	388, Brt.	*Enceladus* faint.
21	12 26 30	269.84	12 27 32	51.14	2 . 2	3	388, Brt.	
21	12 40 58	268.55	12 10 50	53.89	2 . 2	3	388, Brt.	
1915 Jan. 4	9 4 38	204.15	9 5 58	14.16	2 . 2	2	388 Brt.	
4	9 18 53	200.21	9 19 2	12.86	2 . 2	2	388, Brt.	
9	9 39 18	287.92	9 38 18	67.75	2 . 2	2	367b, Brt.	
9	9 55 35	285.93	9 55 45	70.12	2 . 2	2	367b, Brt.	
13	8 29 56	287.68	8 29 56	63.06	2 . 2	3	388 Brt.	
13	8 45 58	286.01	8 47 48	65.67	2 . 2	3	388, Brt.	
15	10 32 19	227.92	10 32 2	38.05	2 . 2	2	388, Brt.	
15	10 46 32	225.38	10 45 12	36.72	2 . 2	2	388, Brt.	
21	9 16 22	136.56	9 16 42	6.23	2 . 2	2	367b, Red	
21	9 38 36	136.96	9 38 52	5.83	2 . 2	2	367b, Red	*Enceladus* faint.
Feb. 10	8 47 35	283.58	8 45 58	10.00	2 . 2	2	388, Brt.	
10	9 8 8	281.93	9 10 8	9.58	2 . 2	2	367b, Brt.	
17	10 34 53	88.03	10 33 10	79.88	2 . 2	2-3	388, Brt.	
17	10 55 10	86.84	10 57 16	80.83	2 . 2	2-3	367b, Brt.	First p with power 388.
18	9 16 49	253.97	9 13 42	79.79	2 . 2	2	367b, Brt.	*Enceladus* faint.
18	9 39 6	252.24	9 39 8	77.57	2 . 2	2	367b, Brt.	
Mar. 13	10 12 4	247.43	10 11 14	38.97	2 . 2	2 3		*Enceladus* too faint to finish.
27	7 31 40	24.62	7 33 40	7.00	2 . 2	2-3	388, Brt.	
27	7 56 16	23.71	7 53 47	6.67	2 . 2	2 3	388, Brt.	
31	7 51 11	306.40	7 49 22	32.31	2 . 2	2 3	388, Red	
31	8 13 12	302.37	8 13 14	33.61	2 . 2	2 3	388, Red	
			Tethys-Dione					
1914 Sept. 26	13 52 45	242.96	13 51 1	18.18	2 . 2	2 3	388, Brt.	
26	14 15 1	240.23	14 16 0	18.80	2 . 2	2 3	388, Brt.	
Oct. 19	13 6 23	340.50	13 4 51	23.84	2 . 2	2	388, Brt.	
19	14 15 36	326.50	14 16 41	25.00	2 . 2	2	388, Brt.	Haze.
21	14 27 30	172.51	14 27 58	25.57	2 . 2	3-4	388, Brt.	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
			Tethys-Dione (Continued)					
	h m	°	h m s	"				
1914 Oct. 21	11 13 29	168.69	11 12 25	25.61	2 , 2	3 4	388, Brt.	
28	13 21 53	295.90	13 21 56	61.52	2 , 2	3	388, Brt.	
28	13 46 16	293.52	13 18 22	61.11	2 , 2	3	388, Brt.	Haze.
30	13 19 16	19.06	13 22 18	16.35	1 , 1	3	388, Brt.	
30	11 17 36	6.22	11 11 11	13.16	2 , 2	3	388, Brt.	
30	11 31 34	2.13	11 29 5	13.03	2 , 2	3	388, Brt.	
31	12 36 18	238.26	12 36 20	18.53	2 , 2	3	388, Brt.	
31	12 49 58	236.93	12 50 12	17.25	2 , 2	3	388, Brt.	
Nov. 2	13 28 15	61.31	13 28 51	38.39	2 , 2	3 4	388, Brt.	
2	13 47 30	60.11	13 47 18	38.09	2 , 2	3 4	388, Brt.	
3	11 0 58	256.01	11 2 25	87.92	2 , 2	3	388, Brt.	
3	11 16 11	255.16	11 16 11	88.02	2 , 2	3	388, Brt.	Moonlight. Haze.
4	13 1 10	89.11	13 1 50	107.17	2 , 2	3	388, Brt.	
4	13 13 50	88.76	13 13 27	108.01	2 , 2	3	388, Brt.	
6	12 11 11	123.98	12 13 21	11.29	2 , 2	2	388, Brt.	
6	13 1 31	121.39	13 5 16	12.32	2 , 2	2	388, Brt.	Moonlight.
9	13 17 22	198.56	13 11 10	12.40	2 , 2	3	388, Brt.	
9	13 35 10	194.03	13 31 40	11.30	2 , 2	3	388, Brt.	
11	12 53 40	249.26	12 53 51	93.94	2 , 2	3	388, Brt.	
13	11 46 32	285.20	11 46 53	22.06	2 , 2	3	388, Brt.	
13	11 58 52	281.79	12 0 14	22.00	2 , 2	3	388, Brt.	
16	13 51 44	293.88	13 51 15	76.56	2 , 2	3	388, Brt.	
16	14 5 59	292.34	14 6 57	78.59	2 , 2	3	388, Brt.	
17	11 17 53	172.61	11 16 58	17.27	2 , 2	2	388, Brt.	
17	12 13 29	166.60	12 5 30	17.26	2 , 2	2	388, Brt.	Haze.
Dec. 11	11 37 11	261.53	11 36 16	16.87	2 , 2	3 4	388, Brt.	
11	11 51 59	263.12	11 53 8	17.37	2 , 2	3 4	388, Brt.	
15	13 35 16	113.65	13 35 12	18.96	2 , 2	3	388, Brt.	
15	13 45 58	112.81	13 46 10	50.13	2 , 2	3	388, Brt.	
22	11 38 18	271.08	11 39 20	95.21	2 , 2	3	388, Brt.	
26	12 11 28	92.06	12 15 18	13.92	2 , 2	3 4	388, Brt.	
26	12 28 6	91.82	12 27 19	14.21	2 , 2	3 4	388, Brt.	
1915 Jan. 13	11 11 31	229.32	11 15 38	13.17	2 , 2	3	388, Brt.	
13	11 59 57	227.75	12 0 39	12.90	2 , 2	3	388, Brt.	Rather faint. Haze.
15	11 7 6	39.94	11 6 10	52.60	2 , 2	2	388, Brt.	
15	11 21 58	38.12	11 22 26	51.27	2 , 2	2	388 Brt.	
20	12 6 10	87.73	12 6 32	39.88	2 , 2	3	388, Brt.	
20	12 19 1	87.07	12 18 51	40.85	2 , 2	3	388, Brt.	
21	11 30 20	287.78	11 32 26	65.87	2 , 2	3	388, Brt.	
21	11 47 24	286.67	11 49 0	67.94	2 , 2	3	388, Brt.	
29	8 51 26	285.34	8 50 12	88.11	2 , 2	3	388, Brt.	
29	9 3 28	284.51	9 1 51	89.71	2 , 2	3	388, Brt.	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
			Tethys-Dione (Continued)					
	h m s	°	h m s	″				
1915 Feb. 9	9 28 4	302.10	9 28 18	64.40	2 , 2	3	388, Brt.	
9	9 44 22	300.05	9 44 45	66.37	2 , 2	3	388, Brt.	
19	8 19 48	91.40	8 20 54	13.96	2 , 2	2	388, Brt.	
19	8 34 54	90.36	8 35 50	14.15	2 , 2	2	388, Brt.	
20	10 34 36	320.57	10 33 32	32.44	2 , 2	2	388, Brt.	
20	10 50 37	317.85	10 49 13	33.54	2 , 2	2	388, Brt.	Haze.
21	10 17 2	197.28	10 16 10	46.85	2 , 2	3	388, Brt.	
21	10 33 14	193.51	10 32 38	46.24	2 , 2	3	388, Brt.	
27	9 0 41	106.17	9 1 21	74.06	2 , 2	2 3	388, Brt.	
27	9 15 42	105.00	9 16 1	75.50	2 , 2	2 3	388, Brt.	Clouds. Moonlight.
Mar. 9	9 24 26	219.09	9 24 33	8.85	2 , 2	3	388, Brt.	
9	9 44 20	219.93	9 44 14	8.31	2 , 2	3	388, Brt.	
27	8 46 10	314.25	8 46 23	14.08	2 , 2	2 3	388, Brt.	
27	8 30 40	312.41	8 30 54	14.00	2 , 2	2 3	388, Brt.	
31	9 20 42	216.15	9 23 40	53.60	2 , 2	2 3	388, Brt.	
31	9 40 15	213.01	9 39 26	52.12	2 , 2	2 3	388, Brt.	
Apr. 1	7 26 7	69.10	7 26 1	64.24	2 , 2	2	388, Brt.	
1	7 46 4	67.87	7 47 51	62.10	2 , 2	2	388, Brt.	
7	7 52 52	329.90	7 51 18	35.51	2 , 2	3	388, Brt.	
7	8 6 27	326.80	8 6 16	36.01	2 , 2	3	388, Brt.	
			Tethys-Rhea					
1914 Sept. 28	14 31 51	228.35	14 31 41	38.49	2 , 2	3	388, Brt.	
28	15 1 43	226.33	15 2 24	38.80	2 , 2	3	388, Brt.	
Oct. 19	15 51 10	271.46	15 51 0	119.90	2 , 2	2	388, Brt.	
19	16 12 11	270.61	16 12 37	119.88	2 , 2	2	388, Brt.	
21	13 56 7	176.60	13 55 41	38.71	1 , 1	3	388, Brt.	
28	14 57 0	293.87	14 59 23	87.37	2 , 2	3	388, Brt.	
28	15 28 16	291.68	15 40 2	92.18	2 , 2	3	388, Brt.	Haze.
30	12 47 6	112.84	12 47 22	29.64	1 , 1	3	388, Brt.	
31	13 5 42	88.46	13 6 28	105.49	2 , 2	3	388, Brt.	
31	13 19 14	88.49	13 19 14	105.85	2 , 2	3	388, Brt.	
Nov. 2	14 4 24	251.96	14 1 34	18.01	2 , 2	3	388, Brt.	
2	14 17 24	251.85	14 19 14	16.75	2 , 2	3	388, Brt.	
3	13 29 38	240.52	13 29 41	69.17	2 , 2	3	388, Brt.	
3	13 44 36	239.50	13 44 20	69.21	2 , 2	3	388, Brt.	Moonlight.
4	13 26 57	93.52	13 27 8	127.84	2 , 2	3	388, Brt.	
4	13 41 13	93.14	13 40 58	128.07	2 , 2	3	388, Brt.	
5	14 14 18	349.67	14 12 42	32.10	2 , 2	2	388, Brt.	
5	14 38 59	346.19	14 37 10	31.80	2 , 2	2	388, Red	First p with bright field.
9	12 44 29	88.60	12 41 22	13.10	2 , 2	3	388, Brt.	[Moonlight. Haze.
9	12 58 12	88.49	12 59 3	14.11	2 , 2	3	388, Brt.	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
			Tethys-Rhea (Continued)					
	h m s	°	h m s	″				
1914 Nov. 11	12 20 52	259.35	12 20 28	119.59	2 , 2	3	388, Brt.	
11	12 36 8	258.64	12 36 17	118.63	2 , 2	3	388, Brt.	
13	13 0 15	115.05	13 1 26	76.68	2 , 2	2	388, Brt.	
13	13 16 58	113.85	13 17 30	78.30	2 , 2	2	388, Brt.	
16	13 7 20	263.60	13 7 20	91.25	2 , 2	3	388, Brt.	
16	13 31 35	262.74	13 31 28	92.37	2 , 2	3	388, Brt.	
17	13 59 9	122.74	13 59 0	83.85	2 , 2	2-3	388, Brt.	
17	14 14 8	121.16	14 14 20	85.79	2 , 2	2-3	388, Brt.	Haze.
22	13 37 19	117.22	13 37 16	31.17	2 , 2	3	367b, Brt.	
22	13 49 24	117.27	13 49 36	35.03	2 , 2	3	367b, Brt.	
Dec. 15	14 2 12	96.23	14 4 56	73.10	2 , 2	2-3	388, Brt.	
15	14 17 1	95.98	14 16 18	74.68	2 , 2	2-3	388, Brt.	
21	12 57 15	302.22	12 55 14	26.55	2 , 2	3-4	388, Brt.	
21	13 13 32	303.13	13 12 24	26.01	2 , 2	3-4	388, Brt.	
26	13 38 50	267.76	13 37 32	137.62	2 , 2	3	388, Brt.	
26	13 53 54	267.32	13 53 0	137.87	2 , 2	3	388, Brt.	
1915 Jan. 5	9 57 26	225.07	9 57 8	83.31	2 , 2	2	388, Brt.	
5	10 17 10	223.06	10 16 18	80.84	2 , 2	2	388, Brt.	Haze.
8	12 40 36	296.57	12 40 16	93.66	2 , 2	2	388, Brt.	
8	12 58 36	295.18	13 0 20	95.57	2 , 2	2	388, Brt.	Haze.
15	7 14 10	107.60	7 14 21	99.50	2 , 2	3	388, Brt.	
15	7 29 18	106.50	7 32 5	100.45	2 , 2	3	388, Brt.	
21	10 49 28	27.94	10 49 17	70.28	2 , 2	3	388, Brt.	
21	11 9 31	25.44	11 11 22	68.67	2 , 2	3	388, Brt.	
29	8 26 36	90.09	8 25 36	40.30	2 , 2	3	388, Brt.	
29	8 38 57	90.32	8 39 42	39.93	2 , 2	3	388, Brt.	
Feb. 9	9 59 50	295.11	9 58 17	87.36	2 , 2	2-3	388, Brt.	
9	10 46 31	294.50	10 48 2	89.71	2 , 2	2-3	388, Brt.	
20	11 16 54	96.84	11 21 38	79.14	2 , 2	2-3	388, Brt.	
20	11 39 24	96.21	11 42 15	78.67	2 , 2	2-3	388, Brt.	
21	10 50 26	88.88	10 53 19	52.32	2 , 2	4	388, Brt.	
21	11 8 18	88.95	11 9 23	53.24	2 , 2	4	388, Brt.	
27	9 30 58	274.67	9 31 8	14.50	2 , 2	3-4	388, Brt.	
27	9 46 26	274.50	9 47 5	14.10	2 , 2	3-4	388, Brt.	Moonlight.
Mar. 1	9 21 3	123.97	9 19 8	79.03	2 , 2	3-4	388, Brt.	
1	9 55 37	120.96	9 54 51	82.54	2 , 2	3-4	388, Brt.	Moonlight.
12	7 0 2	313.01	6 58 45	28.84	2 , 2	3	388, Brt.	
12	7 17 4	311.84	7 15 52	28.59	2 , 2	3	388, Brt.	
31	8 37 16	259.37	8 37 38	81.18	2 , 2	2-3	388, Brt.	
31	8 56 54	259.01	8 59 10	79.44	2 , 2	2-3	388, Brt.	

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
			Tethys-Rhea (Continued)					
	h m s	°	h m s	"				
1915 Apr. 1	8 10 34	249.31	8 11 20	42.10	2 2	2 3	388, Brt.	
1	8 28 6	249.16	8 31 53	42.64	2 , 2	2-3	388, Brt.	*Tethys* faint at times.
6	9 23 26	124.46	9 22 8	67.74	2 , 2	3 4	388, Brt.	[Haze.
6	9 53 44	121.70	9 49 2	69.76	2 , 2	3 4	388, Brt.	Both very faint.
7	7 24 40	76.57	7 23 43	41.90	2 , 2	2 3	388, Brt.	
7	7 37 56	76.19	7 37 35	41.15	2 , 2	2 3	388, Brt.	
			Dione-Rhea					
1914 Oct. 18	15 57 35	1.88	15 57 14	59.92	4 , 4	3	388, Brt.	
21	13 22 14	170.09	13 20 4	13.15	4 , 4	3	388, Brt.	
31	12 5 58	80.51	12 5 22	146.60	4 , 4	3	388, Brt.	
Nov. 2	11 49 55	251.51	11 50 15	95.50	2 , 2	3	388, Brt.	
2	12 4 10	250.76	12 4 42	94.63	2 , 2	3	388, Brt.	
3	12 40 56	123.02	12 40 46	30.73	2 , 2	3 4	388, Brt.	
3	12 52 48	121.77	12 51 50	30.43	2 , 2	3 4	388, Brt.	
4	12 35 53	122.78	12 36 6	20.73	2 , 2	2 3	388, Brt.	
4	12 47 24	122.22	12 47 14	21.33	2 , 2	2 3	388, Brt.	
5	12 58 33	78.46	12 59 10	87.30	2 , 2	2	388, Brt.	
5	13 10 36	78.25	13 12 10	86.92	2 , 2	2	388, Brt.	Haze
6	13 29 37	311.56	13 28 52	73.10	2 , 2	2	388, Brt.	
6	13 50 14	309.64	13 48 57	75.13	2 , 2	2	388, Brt.	
9	12 12 12	58.35	12 12 46	76.62	2 , 2	3	388, Brt.	
9	12 30 9	57.37	12 29 16	75.14	2 , 2	3	388, Brt.	
11	14 9 48	287.64	14 10 22	31.08	2 , 2	2	388, Brt.	
11	14 23 45	287.04	14 22 46	31.61	2 , 2	2	388, Brt.	
13	12 20 39	114.70	12 22 32	93.26	2 , 2	3	388, Brt.	
13	12 40 8	113.60	12 41 4	95.26	2 , 2	3	388, Brt.	
17	11 10 26	98.89	11 11 34	42.67	2 , 2	2	388 Prt.	
17	11 23 34	98.84	11 23 45	42.50	2 , 2	2	388, Brt.	Haze.
21	12 58 6	211.06	12 56 56	82.48	2 , 2	2	195, Brt.	
21	13 18 17	211.60	13 20 0	80.50	2 , 2	2	195, Brt.	
23	10 43 24	11.88	10 43 55	47.31	2 , 2	2	367b, Brt.	
23	11 2 13	12.85	10 59 7	46.74	2 , 2	2	367b, Brt.	
Dec. 14	9 53 10	107.93	9 53 52	74.77	2 , 2	3	388, Brt.	
14	10 8 55	107.49	10 9 34	75.02	2 , 2	3	388, Brt.	
15	13 8 42	66.09	13 8 0	28.22	2 , 2	3	388, Brt.	
15	13 19 54	66.81	13 20 47	27.76	2 , 2	3	388, Brt.	
16	15 38 56	57.35	15 38 54	15.44	2 , 2	3	388, Brt.	
16	15 50 23	57.53	15 50 11	15.19	2 , 2	3	388, Brt.	
17	11 28 13	300.27	11 28 28	68.56	2 , 2	2	388, Brt.	
17	11 46 27	298.99	11 48 32	70.69	2 , 2	2	388, Brt.	Haze. Clouds.
22	10 7 14	237.03	10 5 32	26.26	2 , 2	3	388, Brt.	
22	10 25 28	237.13	10 26 18	25.63	2 , 2	3	388, Brt.	

Date	W.M.T.	p	W.M.T.	s	Comp.	Seeing	Power and Illum.	Remarks
				Dione-Rhea (Continued)				
	h m s	°	h m s	″				
1915 Jan. 2	12 1 54	82.52	12 1 2	153.39	2 . 2	3	388, Brt.	
2	12 28 31	81.63	12 31 32	152.67	2 . 2	3	388, Brt.	
8	11 57 51	329.17	11 55 22	71.38	2 . 2	2	388, Brt.	
8	12 19 46	326.54	12 19 6	73.36	2 . 2	2	388, Brt.	Clouds. Haze.
9	10 11 28	257.19	10 15 32	148.39	2 . 2	2	388, Brt.	
9	11 27 24	251.72	11 25 52	141.86	2 . 2	2	388, Brt.	
9	11 14 31	254.15	11 14 5	143.50	2 . 2	2	388, Brt.	
13	11 8 11	321.35	11 9 17	31.92	2 . 2	2-3	388, Brt.	
13	11 22 0	320.32	11 21 1	32.49	2 . 2	2-3	388, Brt.	
15	11 44 36	122.02	11 43 12	94.04	2 . 2	2-3	388, Brt.	
15	11 59 4	120.76	12 0 52	95.94	2 . 2	2-3	388, Brt.	
28	11 1 50	230.63	11 2 36	79.03	2 . 2	3-4	388, Brt.	
28	11 16 12	229.52	11 16 35	78.07	2 . 2	3-4	388, Brt.	
Feb. 9	10 31 32	287.38	10 31 30	19.80	2 . 2	2-3	388, Brt.	
9	10 44 11	287.71	10 43 12	20.18	2 . 2	2-3	388, Brt.	
10	9 32 10	267.38	9 33 7	67.61	2 . 2	2	388, Brt.	
10	9 50 12	266.88	9 52 18	68.39	2 . 2	2	388, Brt.	
18	8 27 31	327.69	8 28 38	57.56	2 . 2	2-3	388, Brt.	
18	8 45 36	325.50	8 45 36	58.98	2 . 2	2-3	388, Brt.	
Mar. 4	7 35 38	97.64	7 34 56	56.39	2 . 2	2-3	388, Brt.	
4	7 52 3	96.92	7 55 13	56.48	2 . 2	2-3	388, Brt.	Moonlight.
9	8 53 35	262.08	8 51 48	25.97	2 . 2	3	388, Brt.	
9	9 8 9	261.94	9 8 28	26.72	2 . 2	3	388, Brt.	
13	7 15 44	266.34	7 15 50	134.40	2 . 2	2	388, Brt.	
13	7 32 1	265.92	7 30 48	134.20	2 . 2	2	388, Brt.	
18	8 17 10	265.94	8 16 52	147.25	2 . 2	2	388, Brt.	
18	8 32 31	265.26	8 35 52	148.19	2 . 2	2	388, Brt.	
Apr. 6	8 36 0	226.20	8 35 24	20.64	2 . 2	3	388, Brt.	
6	8 51 28	221.86	8 50 28	21.47	2 . 2	3	388, Brt.	
				Rhea-Titan				
1914 Oct. 1	11 1 12	73.528	11 4 31	207.24	1 . 4	2-3	388, Brt.	
18	11 31 48	28.100	11 33 29	53.93	1 . 4	3	388, Brt.	
24	12 31 38	289.568	12 34 47	201.27	1 . 4	3	388, Brt.	
27	11 44 16	183.608	11 43 32	123.40	1 . 4	3	388, Brt.	
30	12 1 39	83.269	12 1 2	155.24	1 . 4	3	388, Brt.	
31	13 10 27	88.531	13 10 19	149.69	4 . 1	3	388, Brt.	
Nov. 2	11 12 0	67.752	11 11 50	228.62	1 . 4	3	388, Brt.	Moonlight.
3	12 17 17	33.869	12 18 25	151.25	1 . 4	3	388, Brt.	
4	12 14 30	311.447	12 15 51	134.97	1 . 4	2-3	388, Brt.	Moonlight.
5	13 31 11	281.457	13 31 28	147.98	1 . 4	2	388, Brt.	Haze.

Rhea-Titan (Continued)

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
	h m s	°	h m s	″				
1914 Nov. 7	11 51 25	284.263	11 52 38	123.46	1 , 4	3-4	388, Brt.	Clouds.
9	11 38 18	253.553	11 40 38	269.38	4 , 4	3	388, Brt.	
13	13 42 25	157.679	13 41 30	66.15	2 , 2	2	388, Brt.	
13	13 54 43	157.751	13 54 12	66.79	2 , 2	2	388, Brt.	
16	11 9 44	80.445	11 11 10	287.21	4 , 4	3-4	388, Brt.	
20	11 26 56	36.899	11 27 13	104.70	4 , 4	3	388, Brt.	
22	11 51 38	282.017	11 53 51	246.14	4 , 4	2-3	388, Brt.	
Dec. 12	11 59 18	205.987	11 59 23	132.04	4 , 4	2	388, Brt.	Haze.
14	10 30 44	152.474	10 30 20	57.34	2 , 2	3	388, Brt.	
14	10 44 11	153.098	10 43 54	57.47	2 , 2	3	388 Brt.	
16	13 3 50	114.413	13 3 50	189.95	2 , 2	2-3	388, Brt.	
16	13 28 28	113.807	13 27 14	192.14	2 , 2	2-3	388, Brt.	
22	10 51 48	23.179	10 51 20	113.77	2 , 2	3	388, Brt.	
22	11 11 1	22.382	11 12 1	113.56	2 , 2	3	388, Brt.	
23	11 18 49	307.095	11 16 56	168.75	2 , 2	2	388, Brt.	
23	11 38 46	306.367	11 38 12	171.16	2 , 2	2	388, Brt.	Haze.
1915 Jan. 2	11 22 4	93.021	11 21 58	118.14	2 , 2	3	388, Brt.	
2	11 43 57	93.257	11 44 30	118.31	2 , 2	3	388, Brt.	
5	11 58 39	51.269	12 5 18	197.79	2 , 2	2	388, Brt.	
5	12 23 48	50.664	12 23 13	196.70	2 , 2	2	388, Brt.	Haze.
8	13 16 56	288.378	13 16 4	86.53	2 , 2	2	388, Brt.	
8	13 33 5	288.504	13 34 53	86.90	2 , 2	2	388, Brt.	Haze.
9	12 1 22	295.378	12 3 12	106.18	2 , 2	2	388, Brt.	
9	12 17 46	295.325	12 19 33	107.48	2 , 2	2	388, Brt.	
14	8 8 34	150.102	8 8 30	72.07	2 , 2	2	388, Brt.	
14	8 24 43	150.159	8 23 26	71.90	2 , 2	2	388, Brt.	Haze. Fog.
20	11 27 18	49.511	11 26 52	100.16	2 , 2	3	388, Brt.	
20	11 44 57	49.193	11 45 11	98.61	2 , 2	3	388, Brt.	
28	9 57 2	257.017	9 58 30	150.17	2 , 2	2-3	388, Brt.	
28	10 21 13	256.929	10 22 6	150.77	2 , 2	2-3	388, Brt.	
Feb. 9	11 7 20	302.462	11 8 22	70.52	2 , 2	2-3	388, Brt.	
9	11 26 46	302.563	11 26 20	70.60	2 , 2	2-3	388, Brt.	
10	10 13 32	294.926	10 16 16	128.37	2 , 2	2	388, Brt.	
10	10 40 33	294.467	10 39 16	130.12	2 , 4	2	388, Brt.	
17	9 49 48	136.888	9 49 48	131.79	2 , 2	2	388, Brt.	
17	10 12 59	135.929	10 12 18	133.20	2 , 2	2	388, Brt.	
19	10 36 58	81.691	10 36 22	263.32	2 , 2	2	388, Brt.	
19	11 0 28	81.448	11 0 25	261.79	2 , 2	2	388, Brt.	
Mar. 1	8 19 52	257.169	8 22 20	175.14	2 , 2	3	388, Brt.	
1	8 46 23	256.897	8 48 8	176.06	2 , 2	3	388, Brt.	Moonlight.

Rhea-Titan (Continued)

Date		W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
		h m		h m s	″				
1915 Mar.	9	7 58 14	68.577	7 56 58	237.08	2, 2	2	388, Brt.	
	9	8 30 30	68.069	8 33 0	235.59	2, 2	2	388, Brt.	
	18	9 2 38	182.399	9 1 2	62.49	2, 2	2	388, Brt.	
	18	9 15 20	182.146	9 16 8	61.77	2, 2	2	388, Brt.	Haze.
	29	8 22 51	281.539	8 25 12	205.66	2, 2	3	388, Brt.	
	29	8 18 36	281.308	8 17 51	206.02	2, 2	3	388, Brt.	
Apr.	6	7 31 36	99.871	7 31 52	113.00	2, 2	2 3	388, Brt.	
	6	7 50 11	99.842	7 49 16	112.46	2, 2	2 3	388, Brt.	
	7	8 26 11	109.547	8 29 9	91.21	2, 2	2 3	388, Brt.	
	7	8 43 2	109.582	8 45 27	91.37	2, 2	2 3	388, Brt.	

Seeing, 2 = good, 3 = fair, 4 = poor. Power and Illum., b = occulting bar over planet; Brt. = bright field, Red = red wires.

Clark II micrometer was used from 1914 Oct. 24 to Nov. 21. Value of one revolution = 9″.9329 +0″.0000 525 (t − 50° F.) +0″.0255 (1$^{\rm in}$.280 − focal scale).

Repsold micrometer was used from 1914 Sept. 26 to Oct. 24 and from 1914 Nov. 21 to 1915 Apr. 12. Value of one revolution = 20″.8332 +0″.0000 27 (t − 50° F.) +0$^{\rm m}$.0535 (0$^{\rm in}$.840 − focal scale).

U. S. Naval Observatory, Washington, D. C.,
1915 [illegible].

OCCULTATIONS BY THE *MOON*, 1921-22,

OBSERVED WITH THE 26 AND 12-INCH REFRACTORS OF THE U. S. NAVAL OBSERVATORY,

BY ASAPH HALL AND ERNEST CLARE BOWER.

[Communicated by CAPTAIN W. D. MACDOUGALL, U. S. Navy, Superintendent of the U. S. Naval Observatory.]

Date		Object		Phen	26-Inch W. Sid. T.	26-Inch W. M. T.	See'g	Pow'r	Obs.	Rem.	12-Inch W. Sid. T.	12-Inch W. M. T.	See'g	Pow'r	Obs.	Rem.
					h m s	h m s					h m s	h m s				
May	21	88B.	Sco	DB	12 33 0.9	8 36 25.3	p	183	Hl.	ufe						
	21	88B.	Sco	RD	13 27 6.1	9 30 21.6	p	183	Hl.	120 fe						
July	18	σ	Sgr	DD	22 55 38.0	15 9 17.6	p	178b	B	H½ f						
Aug.	10	ι	Lib	DD	19 5 31.9	9 19 23.2	p	183	B	H						
Sept.	18	ε	Psc	DB	3 12 33.0	15 51 39.3	p	183	Hl.	c						
	18	ε	Psc	RD	4 32 51.7	16 11 52.7	p	183	Hl.	le						
	18	ε	Psc, nf	DB	3 13 31.8	15 52 37.9	p	183	Hl.	c						
	18	ε	Psc, nf	RD	4 33 15.4	16 12 12.9	p	183	Hl.	e						
Oct.	15	171B.	Psc	DD	5 11 13.0	16 3 50.1	f	183	Hl.		5 11 13.1	16 3 50.5	p	160	B	1 1½
	20	415	Tau	DB	5 32 11.1	15 35 10.1	p	183	Hl.	u						
	20	415	Tau	RD	6 23 59.2	16 26 50.1	p	183	Hl.	H						
	21	292B.	Ori	DB	2 56 15.7	12 56 11.6	f	183	Hl.							
	21	292B.	Ori	RD	4 8 5.6	14 7 22.7	f	183	Hl.		4 8 5.7	14 7 22.9	f	115	B	12
	22	λ	Gem	DB	2 14 2.2	12 9 42.2	f	183	Hl.		2 14 2.6	12 9 42.5	f	160b	B	13
	22	λ	Gem	RD	3 17 36.7	13 13 6.2	f	183	Hl.	12	3 17 36.8	13 13 6.3	f	115	B	H½

Date	Object	Phen.	26-Inch						12-Inch					
			W. Sid. T.	W. M. T.	See'g	Pow'r	Obs.	Rem.	W. Sid. T.	W. M. T.	See'g	Pow'r	Obs.	Rem.
1921			h m s	h m s					h m s	h m s				
Oct. 22	λ Gem. nf	RD	3 17 45.5	13 13 15.0	f	183	HL							
Dec. 15	26 Gem	DB	5 59 58.3	12 22 42.1	f	183	HL		5 59 58.9	12 22 42.7	f	160b	B	±20
15	26 Gem	RD	7 18 48.4	13 41 19.4	f	183	HL	12	7 18 18.4	13 41 19.4	f	160b	B	11
1922 Jan. 6	263B. Psc	RB	3 30 22.9	8 27 1.2	f	183	HL	vl c	3 30 22.8	8 27 1.1	f	115	B	130 ±20
12	λ Gem	DD	9 12 2.8	13 44 9.6	p	183	HL		9 12 2.3	13 44 9.2	p	160b	B	±5
12	λ Gem	RB	10 6 40.4	11 38 38.3	f	183	HL	120 c	10 6 36.5	11 38 34.4	p	160b	B	18 ±5
13	30B. Cnc	DB	1 5 54.5	8 34 55.6	p	183	HL							
13	30B. Cnc	RD	5 1 32.1	9 30 24.1	vp	183	HL	vl c	5 1 20.4	9 30 12.4	p	160b	B	115 ±5
14	209B. Cnc	DB	3 13 22.1	7 38 35.9	vp	183	HL	u						
14	209B. Cnc	RD	4 10 4.9	8 35 9.4	p	183	HL	12	4 10 4.8	8 35 9.2	p	160b	B	12
Feb. 2	88 Psc	DD	5 34 7.3	8 44 15.8	p	183	HL	gk						
2	88 Psc	RB	5 58 46.1	9 8 50.5	p	183	HL	vl vfc						
8	26 Gem	DD	7 35 54.2	10 22 7.2	f	183	HL	p c	7 35 51.2	10 22 7.2	g	115	B	11½
8	26 Gem	RB	8 49 11.0	11 35 12.1	f	183	HL	120 sc	8 49 10.2	11 35 11.2	f	115	B	130 ±10
Mar. 8	λ Gem	DD	9 56 14.7	10 51 59.4	f	183	HL	11	9 56 14.8	10 51 59.5	g	115	B	11
8	λ Gem	RB	11 3 21.1	11 58 54.7	f	183	HL	15	11 3 21.3	11 58 55.0	f	160b	B	15
8	λ Gem. nf	DD							9 56 27.2	10 52 11.9	g	115	B	11
12	75 Leo	DD	10 23 40.4	11 3 36.7	g	183	HL		10 23 40.2	11 3 36.8	f	115	B	11
12	75 Leo	RB	11 38 19.2	12 18 33.4	f	183	HL	15	11 38 19.0	12 18 33.2	g	160b	B	115 ±5
12	76 Leo	DD	11 36 10.3	12 16 24.9	g	183	HL		11 36 10.3	12 16 24.9	g	160b	B	±3
12	76 Leo	RB	12 45 57.4	13 25 30.6	f	183	HL	120	12 45 59.4	13 25 32.6	p	160b	B	130 ±10
12	79 Leo	RB							15 10 24.8	15 49 34.3	p	160b	B	120 ±10
Apr. 8	35 Sex, sp	DD	7 53 10.0	6 47 21.7	f	183	HL	c						
8	35 Sex, sp	RB	9 2 1.0	7 56 1.4	f	183	HL	120 c						
8	35 Sex	DD	7 53 15.3	6 47 27.0	f	183	HL	c	7 53 15.1	6 47 27.1	p	115	B	11
8	35 Sex	RB	9 2 40.9	7 56 41.3	f	183	HL	110 c						
12	μ Lib	DB	16 48 20.0	15 25 20.4	p	183	HL	c	16 48 23.3	15 25 23.8	p	160b	B	±10
12	μ Lib	RD	17 56 27.3	16 33 16.6	f	183	HL	12	17 56 27.4	16 33 16.6	f	160b	B	11
June 12	27G. Cap	DB	19 22 49.6	13 59 31.3	f	183	HL		19 22 51.2	13 59 35.9	f	160b	B	±10
12	27G. Cap	RD	20 41 52.6	15 18 24.4	f	183	HL	12	20 41 52.9	15 18 24.6	f	115	B	12
July 8	ρ Sgr	DB	21 53 28.4	14 17 31.8	p	183	HL							
11	96B. Aqr	DB	22 29 47.8	15 12 0.4	f	183	HL		22 29 49.6	15 12 2.2	f	160b	B	110 ±20
11	96B. Aqr	RD	23 52 30.1	16 34 29.2	f	183	HL	11 sd	23 52 30.1	16 34 29.2	f	115	B	12 d
Aug. 6	τ Cap	DD	16 54 41.2	7 55 35.1	p	183	HL							
6	τ Cap	RB	18 14 40.8	9 15 21.6	f	183	HL	h						
18	26 Gem	DB	1 29 7.0	15 41 25.7	p	183	HL	c						
18	26 Gem	RD	2 13 34.1	16 25 45.6	f	183	HL	11 kc						
28	θ Lib	DD	17 32 16.8	7 6 34.5	f	183	B	11						
28	θ Lib	RB	18 25 15.2	7 59 24.3	f	178b	B	12						
Sept. 12	70 Tau	DB	23 41 53.6	12 16 12.2	vp	178b	B	±20						
12	70 Tau	RD	0 0 59.6	12 35 15.1	vp	183	B	13						
12	75 Tau	DB	1 0 45.3	13 34 51.0	vp	178b	B	±10						

Date		Object		Ph.	26-Inch W. Sid. T.	26-Inch W. M. T.	26-Inch See'g	26-Inch Pow'r	26-Inch Obs.	26-Inch Rem.	12-Inch W. Sid. T.	12-Inch W. M. T.	12-Inch See'g	12-Inch Pow'r	12-Inch Obs.	12-Inch Rem.
					h m s	h m s					h m s	h m s				
Sept.	12	75	Tau	RD	2 19 23.8	14 53 16.6	p	183	B	12						
	12	ρ	Tau	DB	6 18 30.2	18 51 13.9	p	183	B	11 d						
	12	α	Tau	RD	7 14 54.2	19 47 58.6	p	183	B	11 d						
	13	111	Tau	DB	2 11 3.7	15 13 56.5	vp	178b	B	±10						
	14	292B.	Ori	DB	3 37 27.0	16 3 15.2	f	178b	B	e5±5						
	14	292B.	Ori	RD	4 56 51.5	17 22 26.7	f	183	B	11						
	15	λ	Gem	DB	3 45 51.3	16 7 45.2	f	178b	B	11						
	15	λ	Gem	RD	4 25 44.2	16 47 25.6	f	183	B	11						
	15	λ	Gem nf	RD	4 26 22.9	16 48 7.2	f	183	B	11						
	16	30B.	Cnc	RD	4 59 53.9	11 18 6.3	p	183	B	11½						
	28	ρ	Sgr	DD	21 25 37.4	8 57 23.9	f	183	HL	12						
	28	ρ	Sgr	RB	22 34 16.0	10 5 51.2	p	183	HL	110						
Oct.	1	96B.	Aqr	DD	23 33 21.1	10 52 58.9	f	183	HL	g						
	1	96B.	Aqr	RB	0 50 39.5	12 10 4.6	f	183	HL	110						
	3	316B.	Aqr	DD	19 9 32.6	6 22 4.8	p	183	HL	12						
	3	316B.	Aqr	RB	20 26 32.4	7 38 49.0	f	183	HL	120 f						
Nov.	8	26	Gem	DB	5 9 51.4	13 59 9.6	p	183	HL							
	8	26	Gem	RD	6 36 38.5	15 25 12.5	f	183	HL							
	10	29	Cnc	DB	3 6 41.9	11 48 28.5	p	183	HL							
	10	29	Cnc	RD	3 51 16.0	12 32 55.2	f	183	HL	12						
	21	53B.	Aqr	DD	21 57 41.8	5 15 19.3	p	183	HL	cw						
Dec.	22	λ	Cap	DD	0 1 19.1	5 58 28.1	p	183	HL	kc	0 1 19.6	5 58 28.3	f	115	B	11½c
	26	155B.	Psc	DD	23 11 35.8	5 23 4.4	p	183	B	11						

Ph.: DD = disappearance dark limb, DB = disappearance bright limb, RD = reappearance dark limb, RB = reappearance bright limb.

Power: b = occulting bar attached to eyepiece.

Obs.: HL = HALL, B = BOWER.

Remarks: c = cloudy, d = daylight, e = early, f = star faint, g = gradual, h = hazy, k = dark limb visible, l = late, o = eyepiece fogged, p = poor observation, s = some, a little, u = uncertain, v = very, w = windy. Numbers indicate estimate in tenths of seconds: 12 ±1 = late 0s.2 ±0s.1, 125 ±10 = late 2½s ±1s, etc.

The clock corrections used to 1923 Jan. 1 are based on Boss' *Preliminary General Catalogue*.

U. S. Naval Observatory, Washington, D. C.,
1923, Jan. 9.

A REVISED LIST OF THE OLIVIER DOUBLE STARS,

By CHAS. P. OLIVIER.

In a series of eleven papers on double stars appearing in various astronomical publications from 1906 to 1922 the writer has announced the discovery of over a hundred new double stars, found more or less casually during the prosecution of the work. Following the best modern practice a limit of 5″ separation has been used. As these new doubles are scattered through many different papers it would be convenient to have them all collected into one paper, with corrections and remeasures when available. In the following pages this has been done and short notes are here added.

In all 110 doubles are found in the list, of which it is now known that three were previously discovered by others. Of these 110, 35 have northern and 75 southern declinations, while 44 appear in either the *B. D.* or *C. P. D. Catalogues*. As to distances they are as

No.	R.A. 1920	Decl. 1920	Magn.	Catalogue	p	Δ	Date 1900+	Nights	Remarks
	h m s	° ′			°	″			
1	3 48 5	−14 0	9.5 10.0	*B. D.* −14.762	273.8	2.82	06.913	3	
2	4 42 57	−21 35	9.0 11.2	*C. P. D.* −21.649	221.3	3.80	06.896	2	
3	4 43 5	−22 55	10.0 10.6	*C. P. D.* −23.615	59.1	1.31	06.901	3	
4	5 35 16	−21 40	10.0 10.3	*C. P. D.* −21.887	69.8	1.88	06.901	3	
5	7 45 11	−19 10	9.0 11.2		194.2	2.81	06.916	2	Cannot find, 1921.
6	7 51 27	−20 33	9.5 10.8		49.6	2.93	07.033	2	
7	23 48	+37 14	9.5 9.6		350.	4.8	20.678	1	Near J. C. 3933
8	18 36	−16 7	9.7 10.4		71.0	2.08	07.648	3	
9	2 38 54	− 1 55	9.5 10.5		328.4	2.85	08.382	2	
10	7 49	−20 43	10.0 10.5		353.8	2.64	07.167	1	
11	9 41	−15 46	9.0 9.5		355.3	1.72	08.265	1	
12	11 19	− 9 54	9.5 10.3		117.6	1.35	07.436	1	
13	18 13	−16 2	8.5 10.0		178.9	3.68	07.583	1	
14	18 34 14	+39 07	9.0 10.0		345.6	1.08	08.756	1	
15	18 35 7	+40 10	8.0 9.0	*B. D.* +40.3437?	23.4	1.91	08.756	1	
16	16 53 6	−30 7	8.6 9.0	Y3 7144	189.8	1.50	09.622	2	= λ [illegible]: A − C = 19″
17	18 13 19	−35 6	8.3 9.5	*C. P. D.* −35.7875	250.6	5.23	09.612	3	
18	18 13 45	−35 12	8.8 9.6	*C. P. D.* −35.7881	120.3	1.91	09.626	4	
19	18 21 17	−36 28	9.2 11.0	*C. P. D.* −36.8241	263.0	3.23	09.611	2	
20	18 39 24	−33 27	9.0 9.4	*C. P. D.* −33.5255	352.4	0.75	09.592	3	
21	18 44 30	−29 11	8.9 9.5	*C. P. D.* −29.5730	155.2	1.70	09.599	4	
22	19 7 8	−33 11	8.2 8.7	*C. P. D.* −33.5517	246.9	0.66	09.608	4	
23	19 32 9	−34 54	9.0 9.1	*C. P. D.* −34.8485	156.7	0.69	09.623	1	
24	19 45 45	−26 22	9.1 9.4	*C. P. D.* −26.6854	44.9	0.88	09.608	2	
25	20 16 49	−36 45	9.4 10.6		256.7	1.44	09.624	2	
26	20 23 7	−31 28	8.8 11.1	*C. P. D.* −31.6270	333.7	1.82	09.615	4	
27	7 21 24	−33 46	9.3 10.5	*C. P. D.* −33.1467	45.9	4.27	10.136	4	
28	7 41 25	−33 13	9.1 9.5		120.8	4.82	10.108	2	Near Oл 29
29	7 42 08	−33 34	8.9 9.2	*C. P. D.* −33.1737	174.7	2.84	10.107	3	
30	7 58 1	−29 14	9.1 9.3	*C. P. D.* −29.2230	69.1	1.01	10.245	2	
31	8 3 7	−22 37	9.3 9.9	*C. P. D.* −22.3419	0.7	2.77	10.188	3	Triple. A − C = 0″.8
32	8 14 35	−25 21	10.6 11.8	*C. P. D.* −25.3480	307.1	1.46	10.167	1	
33	8 14 49	−30 42	9.3 9.7	*C. P. D.* −30.2387	42.0	3.72	10.249	3	
34	8 22 39	−30 25	9.0 10.5	*C. P. D.* −30.2477	356.2	3.50	10.218	2	
35	8 39 0	−25 6	9.7 10.1	*C. P. D.* −24.3807	310.2	3.32	10.178	2	
36	8 41 24	−24 50	9.5 10.1	*C. P. D.* −24.3822	136.5	1.18	10.176	3	
37	8 41 34	−24 50	9.1 10.3	*C. P. D.* −24.3823	201.0	1.18	10.176	3	
38	8 50 25	−35 12	8.6 9.1	*C. P. D.* −35.2991	320.8	1.54	10.132	2	
39	9 9 25	−33 47	8.6 10.8	*C. P. D.* −33.2529	226.0	4.00	10.132	2	
40	9 28 53	−25 17	9.5 10.4	*C. P. D.* −25.4183	10.1	1.38	10.234	3	
41	9 47 29	−27 44	8.9 9.0	*C. P. D.* −27.3889	171.2	1.37	10.234	3	
42	10 51 19	−30 34	9.2 10.3	*C. P. D.* −30.3232	154.3	3.29	10.234	3	A − C = 35″
43	10 51 34	−30 51	9.0 9.4	*C. P. D.* −30.3235	100.2	1.98	10.257	2	
44	12 6 0	−33 22	8.1 10.0	*C. P. D.* −33.3204	325.1	2.92	10.268	1	
45	17 42 42	−34 27	9.8 11.3		38.5	1.6±	10.570	2	Near *C.P.D.* −31.7115
46	17 45 21	−31 1	9.6 10.0	*C. P. D.* −31.7183	291.2	2.25	10.570	2	
47	18 0 25	−34 19	8.7 10.0	*C. P. D.* −34.7579	119.5	1.63	10.570	2	
48	18 4 31	−29 29	9.5 10.0	*C. P. D.* −29.5336	186.8	2.82	10.601	2	
49	20 15 13	−29 25	9.4 9.8	*C. P. D.* −29.6279	187.4	4.18	10.206	2	= Howe 53
50	20 40 54	−19 46	9.2 10.2		187.5	3.71	10.725	3	
51	23 05 3	− 4 29	9.0 10.6	*B. D.* − 4.5829	346.5	3.11	11.790	2	

No.	R. A. 1920	Decl. 1920	Magn.		Catalogue		p	Δ	Date 1900+	Nights	Remarks
	h m s	° ′					°	″			
52	2 1 16	1 15	8.5	9.0	*B. D.*	1.332	127.0	4.84	16.914	2	= A 2601
53	7 59 29	22 31	9.7	12.			337.1	2.58	16.604	3	
54	8 1 0	22 34	9.1	10.9			76.1	3.70	16.991	3	
55	2 54	1 52	9.4	12.			54.1	2.42	17.869	2	
56	5 19 37	0 3	9.8	10.9			110.4	2.34	19.274	3	
57	5 33 32	− 1 56	10.5	10.6			22.2	0.66	20.334	2	
58	7 11 14	19 7	9.7	10.6			113.2	1.33	16.256	3	*
59	7 16 15	+11 18	9.8	11.0			16.8	2.54	18.934	2	S. f. *B. D.* +11 .1693
60	7 59 22	+12 53	9.3	10.0	*B. D.*	+13.1827	108.2	3.75	17.912	2	
61	8 6	−25 19	10.	11.			176.3	1.43	17.907	2	
62	8 21 13	19 32	9.5	9.7			189.	0.5	17.814	1	
63	19 7 39	+ 9 27	9.7	10.7			64.0	1.50	17.725	2	
64	19 27 9	+11 27	10.1	10.6			264.9	1.33	17.725	2	
65	22 15	+50 11	9.6	11.4			22	3.50	22.267	2	* just p. J. C. 3712
66	6 15 17	− 2 18	9.5	9.8			109.1	3.16	16.843	1	Ph.
67	6 18 10	+22 12	8.8	10.			37.7	4.95	17.784	1	Ph.
68	7 18 1	−13 54	11.	12.			121.7	3.04	16.815	1	Ph.
69	8 12 38	−13 52	11.5	12.			320.3	2.63	17.509	6	Ph.
70	11 30 19	−11 12	9	11.	*B. D.*	−11.229?	109.2	3.14	19.338	1	Ph.
71	19 12 15	+18 20	9.5	9.6			168.8	1.31	17.143	3	Ph.
72	19 13 11	+18 27	9.5	9.5			9.9	1.31	19.395	3	Ph.
73	20 9 32	+20 58	9.8	10.8			132.5	1.35	18.162	3	Ph.
74	20 21 7	+54 19	11	11.2			40.7	3.79	16.826	1	Ph.
75	20 26 1	+29 52	10.	11.			135.2	1.36	19.641	2	Ph.
76	21 26 20	−22 21	10.	10.7			340 ±	2.5 ±	16.884	1	Ph.
77	23 59 23	+34 8	9.	11	*B. D.*	+33.48	255.6	2.60	19.917	3	Ph.
78	7 12 11	+11 14	9.8	10.5			277.9	1.12	18.204	2	2s f. J. C. 1663
79	7 27	− 1 59	9.8	10.6			205.8	1.99	20.122	2	f. J. C. 1602
80	18 52	−19 55	9.5	11.5			140.	3.2	19.500	1	
81	18 57	13 20	10	12.			330.	3. ±	19.500	1	A − C = 2″; 12^m and 13^m.
82	19 27 36	+18 7	9.8	12.			242.4	1.21	20.036	2	35′ p. J. C. 2937
83	22 16	−23 37	8.8	11.			243.	3.8	15.706	1	
84	23 28 56	+50 13	9.5	9.6			143.4	1.72	21.279	2	
85	17 19 10	+24 51	8.	12.	*B. D.*	+21.3274?	232.9	2.98	19.279	2	
86	0 26 15	+18 53	9.7	12.	*B. D.*	+18.150?	209.1	0.8 ±	21.190	2	near β G. C. 234
87	5 8 10	− 3 10	9.7	9.8			300.1	2.02	21.961	2	
88	17 32	+13 18	9.2	10.2			281.9	2.18	22.377	3	
89	17 17 31	+51 13	9.5	10.			170.4	0.71	21.298	2	
90	18 58 31	+10 11	10.2	10.8			86.8	1.20	20.580	2	
91	19 05 12	+12 56	10.2	10.5			2.3	0.70	20.580	2	
92	19 38	+12 56	9.9	12.			176.2	2.52	20.580	2	
93	19 51 28	+11 11	9.8	11.2			159.9	1.50	21.711	2	
94	5 4 13	+3 36	10.	12.			263.	2.2	21.910	1	
95	5 11 04	+ 1 3	9.2	9.5			202.	0.8	21.910	1	near J. C. 820
96	6 25 07	21 7	9.2	10.	*B. D.*	+21.1259	65.	1.7	21.819	1	
97	7 35 21	10 12	9.8	12.			229.	2.1	20.168	1	p. J. C. 1618
98	14 20 17	+ 1 0	10.	12.			330.	2.2	21.242	1	seen 22.384
99	16 51	17 53	9.	13.5			128.	2.6	21.264	1	
100	17 12	+17 55	9	12.2			187.6	3.30	21.261	2	
101	17 21	2 24	10.	10.6			314.	3.1	21.183	1	just p. J. C. 2504
102	17 17	−20 13	10.	12.			276.	3.	21.261	1	

No.	R. A. 1920	Decl. 1920	Magn.	Catalogue	ρ	Δ	Date 1900+	Nights	Remarks
	h m s	° ′							
103	18 03	−27 40	9.5 11.		271.	4.1	21.242	1	
104	18 14	−18 06	9.5 10.5		213.	3.	21.264	1	
105	18 48	+15 0	10.8 11.8		146.	2.7	21.726	1	
106	19 43 11	+14 58	10. 10.5		215.	3.2	21.726	1	
107	4 29 52	+16 20	10. 10.1		148.9	4.43	17.438	3	Ph.
108	7 49 15	−13 52	11.5 12.		133.8	1.80	16.815	1	Ph.
109	9 12 27	+37 3	10. 11.		60.4	2.30	19.094	2	Ph.
110	20 0	+21 56	10.8 11.0		348.	1 2±	22.509	1	

* Measures discordant.
J. C. Jonckheere's *Catalogue of Double Stars*.
Ph. Discovered on parallax plate.

follows: —

0″.5 to 1″.0	10
1 .0 to 2 .0	35
2 .0 to 3 .0	28
3 .0 to 4 .0	24
4 .0 to 5 .0	12
5 .0	1
	110

It will be seen that 73 are under 3″, while if the third component of Ol 31 is counted we have 11 under 1″.0. Large numbers of faint pairs of from 3″ to 5″ separation have been passed over without any attempt to list them. From the fact that 66 are not identified in catalogues, the magnitudes are on an average fainter than the Aitken stars and probably more nearly comparable to Jonckheere's in this particular. For the 66 unidentified stars, the coördinates were determined at the telescope or on the parallax plates, though in many cases the former were also plotted on the *B. D.* charts and more accurate positions derived. In all cases the declinations may be depended upon to ±1′, but for cases where the right ascensions are given to only whole minutes of time, the error may be larger than ±1 min. This is due to the fine declination and rough hour circle having been used respectively in such cases. The doubles Ol 66 to 77 and Ol 107 to 109, inclusive, were found upon the parallax plates when certain of these were examined by the writer. The rest were found visually, Ol 1 to 15 and Ol 51 to 110, inclusive, with the 26-inch McCormick telescope, Ol 16 to 50, inclusive, with the 12-inch Lick telescope. Remeasures of those first discovered have been undertaken, but only a few have been finished and some others started. A table of these results, whether already published or not, is given.

In closing it should be emphasized that no systematic search for new doubles has ever been attempted and only at occasional intervals has an hour more or less been given to looking for these objects. Most of the 110 listed were picked up quite casually.

Remeasures

No.	Magn.	ρ	Δ	Date	Nights	
1		274.8	3.07	9.131	1	
2		227.4		9.131	1	
2	9.2 11.	223.9	3.99	16.773	3	
3		61.1	1.67	9.131	1	
3	8.7 9.2	60.2	1.50	16.750	2	
4	9.6 9.8	73.2	1.90	10.180	2	
4	9.2 9.4	252.4	1.88	15.845	3	
5					*	
6		48.6	3.64	15.932	2	Motion?
9	9.3 10.7	330.6	2.61	18.503	3	
14	9.1 9.7	338.3	1.02	22.332	2	
15		24.1	1.70	22.332	2	
16	Δm. 0.2	191.6	1.26	21.242	1	
18	Δm. 0.4	119.8	1.82	20.371	2	
20		241.8	0.57	19.500	1	
21		152.8	1.77	19.500	1	
22		266.7	0.58	19.500	1	
24	Δm. 0.4	36.4	0.6±	16.719	1	
31	9.2 10.4	356.4	3.40	16.096	5	AC − E
31	9.5 9.6	167.5	0.80	17.844	1	AC
32	10.3 11.1	299.8	1.52	17.907	2	
59	10. 10.8	17.6	2.52	22.370	2	
60	9.1 9.9	107.2	3.58	22.183	3	
66		110.5	3.48	18.931	3	
78	9.5 10.	280.3	1.39	20.113	1	

*Unable to identify, 1921.

Leander McCormick Observatory,
University of Virginia,
1922, Dec. 8.

OBSERVATIONS OF COMETS,

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

BY ERNEST CLARE BOWER.

[Communicated by CAPTAIN W. D. MACDOUGALL, U. S. Navy, Superintendent of U. S. Naval Observatory.]

G. M. T.	App. α	App. δ	Δα ★	Δδ ★	Comp.	log pα	log pδ	Ap. pl. red. of ★ α	Ap. pl. red. of ★ δ	Seeing	★
			1922 b (Skjellerup)								
	h m s	° ′ ″	m s	′ ″				s	″		
May 23.59472	8 26 19.68	+25 31 9.7	1 23.22	−3 31.6	f25 , 5	9.681	0.603	+0.59	−8.2	f	1
24.59868	8 32 46.31	+26 31 15.2	−0 21.02	+4 15.3	d10 , 8	9.687	0.600	+0.60	−7.9	f	2
29.64559	9 7 14.60	+32 17 51.6	+2 7.22	−8 17.9	f35 , 7	9.732	0.639	+0.64	−5.5	f	3
31.60520	9 23 1.19	+34 38 28.5	−0 9.17	+4 30.9	d10 , 10	9.744	0.495	+0.67	−4.4	p	4
June 20.69885	13 31 58.10	+18 9 0.7	+0 6.12	+1 50.7	d10 , 10	9.771	0.052	+4.38	+8.6	f	6
21.72053	13 45 9.25	+17 50 14.1	+0 17.19	−0 1.2	d14 , 8	9.792	0.204	+4.45	+9.0	p	7
			1922 d (Skjellerup)								
Dec. 5.87487	11 51 28.52	−19 18 46.0	+0 18.44	−1 28.0	d10 , 8	9.544n	0.832	+2.62	−9.3	p	9

May 23. 12m. Faint. Diffuse. Clouds. Very poor observation. May 24. 12m. Faint. May 29. 10m. Visible in 2-in. Poor observation. May 31. Very faint. Moonlight. Clouds. June 20. Very faint. Visible in 5-in. Poor observation. June 21. Faint. Visible in 5-in. Poor observation. Dec. 5. Bright moonlight.

Mean Places of Comparison Stars

★	α	δ	Authority
	h m s	° ′ ″	
1	8 28 12.31	+25 34 52.5	A. G. *Camb.* 1574
2	8 33 6.73	+26 30 37.8	A. G. *Camb.* 1612
3	9 5 3.71	+32 26 15.0	A. G. *Leiden* 3777
4	9 23 9.99	+34 34 2.0	*B. D.* +34.1995(9.5) comp. with 5, 1922 June 23, $\Delta\alpha = -2^m 57^s.75$, $\Delta\delta = +46''.0$, 1922.0.
5	9 26 7.74	+34 33 16.0	½ A. G. (*Leiden* 3888 + *Lund* 1647)
6	13 31 50.90	+18 7 1.1	A. G. *Bonn* 9030
7	13 44 50.34	+17 50 6.6	11m, comp. with 8, 1922 Dec. 29, $\Delta\alpha = +6^m 9^s.58$, $\Delta\delta = +1' 36''.5$, 1922.0.
8	13 38 40.73	+17 48 30.1	A. G. *Bonn* 9082
9	11 51 7.46	19 13 38.7	½ *Astr. Hyd* (−19.4148 37188 + −20.4152, 42922).

U. S. Naval Observatory, Washington, D. C.,
1923, Jan. 31.

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Edward Emerson Barnard

EDWARD EMERSON BARNARD, since 1914 an Associate Editor of the *Astronomical Journal*, and one of the foremost among American scientists, died at his home near the Yerkes Observatory on February 6, 1923. His death brought to a close a career which was among the most notable and inspiring in the annals of American science.

BARNARD was born in Nashville, Tennessee, December 16, 1857. His father died before he was born. His early education was given him by his mother, who died in 1884. Forced by family circumstances to seek employment at an early age, he became a helper in the photographic studio of the brothers CALVERT in Nashville where he received a training in photography which was to be of incalculable aid to him in later life. At this time his attention was directed to astronomy through the reading of DICK's "The Practical Astronomer" and the interest so aroused resulted in the acquisition in 1877 of a five-inch telescope, with which he discovered several comets and made some studies of the planets. His early discoveries, coupled with his earnestness and zeal, attracted the attention of the chancellor and instructors of the newly-established Vanderbilt University and in 1883 he was offered a fellowship there and placed in charge of the six-inch telescope. In spite of his lack of early education he was able by studying night and day to graduate from Vanderbilt in 1887. By this time his astronomical studies, especially his discoveries of comets, had made such a reputation for him that he was selected as a member of the staff of the Lick Observatory.

While at Lick Observatory he continued his visual work on comets and the planets and developed the methods of photographing comets, nebulæ, and the star clouds in the Milky Way. On September 9, 1892 he discovered the fifth moon of *Jupiter*. In recognition of this discovery he was awarded the Lalande Gold Medal of the French Academy of Sciences in 1892 and the following year the Arago Gold Medal of the same academy.

In 1895 BARNARD resigned his position at Lick Observatory to become Professor of Astronomy in the University of Chicago and Astronomer in the Yerkes Observatory, where he remained until his death. His work there has covered micrometric and photographic observations of practically every type of object in the sky.

BARNARD was distinctly an observer. While thoroughly philosophic in his method and in his attitude of mind, his interest was in discovery and description rather than in theory. His published works number more than eight hundred, covering such subjects as: discoveries, positions, photographs and drawings of comets; photographs and drawings of the surface details of the planets; measures of the sizes and positions of the satellites and primaries; light-curves of variable stars and nebulæ; discussions of meteor trails and methods of defining them precisely; discussions of the technique of photography and the performance of lenses; dates and descriptions of auroræ; measures of the more difficult double stars; micrometric measures of the positions of *Eros*; photographs of terrestrial cloud forms; photographs and descriptions of the solar corona; observations of the Zodiacal Light, the luminous night haze and the *Gegenschein*, which he discovered independently in 1883; discovery of the faint star in *Ophiuchus* which has the largest known proper-motion; and discovery and catalogue of the dark nebulæ. His photographs and descriptions of the Milky Way and of comets made at Lick comprise Vol. XI of the *Publications of the Lick Observatory*. His "Atlas of the Milky Way," upon which he was at work at the time of his death will be published by the Carnegie Institution of Washington. An extensive series of triangulations of many of the globular clusters is yet unpublished.

As a result of his long and notable activity BARNARD was the recipient of many honors. In addition to those he received as a direct result of the discovery of the fifth satellite of *Jupiter,* he was awarded in 1897 the Gold Medal of the Royal Astronomical Society of London; in 1900, the Janssen Gold Medal of the French Academy; in 1906, the Janssen Medal of the Société Astronomique de France and in 1917, the Bruce Gold Medal of the Astronomical Society of the Pacific. He was a member of the National Academy, the American Academy, Foreign Associate and Fellow of the Royal Astronomical Society, Honorary Member of the Royal Astronomical Society of Canada, Vice President in 1898 of the American Association, and member of the American Philosophical Society, the American Astronomical Society and the Société Astronomique de France. In 1914 he was made a trustee of the Benjamin Apthorp Gould Fund of the National Academy and an Associate Editor of the *Astronomical Journal.* He was married on January 27, 1881 to Miss Rhoda Calvert, sister of his earliest employers, whose death occurred less than two years before his own.

ON THE REAL MOTIONS OF THE STARS (PAPER 3),

By BENJAMIN BOSS, HARRY RAYMOND AND RALPH E. WILSON.

This paper is a continuation of two of similar title by BENJAMIN BOSS[1,2], and is based upon the system of parallaxes described in the second of them. Parts of this investigation have already been published in abstract form[3,4], but it seems desirable to publish the whole in somewhat greater detail, especially as some of the numerical results have been slightly changed by revision of the data.

The material consists of a list of 520 stars of known radial velocity, proper-motion and parallax ($>0''.005$), collected before the publication of the last list of Mt. Wilson parallaxes[5]. From these the rectangular components of the velocity (x, y, z), the coördinates of the apex, (A, D), and the amount of motion, (V), relative to the assumed motion of the stellar system were computed for each star by the formulae:

$$
\begin{aligned}
x &= \rho \cos \alpha \cos \delta - s\mu \sin \alpha - s\mu' \cos \alpha \sin \delta + x_0 \\
y &= \rho \sin \alpha \cos \delta + s\mu \cos \alpha - s\mu' \sin \alpha \sin \delta + y_0 \\
z &= \rho \sin \delta \qquad\qquad + s\mu' \cos \delta \qquad + z_0 \\
V^2 &= x^2 + y^2 + z^2 \qquad \tan A = y/x \qquad \sin D = z/V
\end{aligned}
$$

These coördinates are on the equatorial system: x is toward the First Point of Aries and z toward the North Pole. The unit of x, y, z, ρ, and V is the kilometer per second, and that of μ and μ' the second of arc per century; $s = .01738\ \pi$. The solar motion was assumed to be 22 km. per second toward $A = 270°$; $D = +30°$; whence $x_0 = 0$, $y_0 = -19.05$, $z_0 = +11.00$. This value was based upon recent work here and at Mt. Wilson[1,6], and seems to be near enough to the true value to leave the distribution of the apices essentially free from systematic distortion on this account.

Among the outstanding features of the *distribution of the apices* is the clustering of the apices of A type stars in the region around right-ascension 270°. These stars represent the *Ursa Major* group moving toward an apex at $A = 282°$; $D = +2°$; with a group motion of 32 kilometers per second[7,*]. The distribution of the apices of late type stars clearly indicates preferential motion in the direction defined by KAPTEYN. Both the giant and dwarf stars show the clustering of the apices about the vertices of preferential motion. In addition the apices of the giants tend to cluster north of the equator from 250° to 300° right-ascension[1]. The peculiar distribution of the apices of the high velocity stars will be mentioned later.

Solutions for the *solar motion* were made by the method of BRAVAIS. The equations are:

$$
\begin{aligned}
x_0 - x &= X_0 = V_0 \cos A_0 \cos D_0 \\
y_0 - y &= Y_0 = V_0 \sin A_0 \cos D_0 \\
z_0 - z &= Z_0 = V_0 \sin D_0
\end{aligned}
$$

The material was divided into "large velocities," > 80 km., and "small velocities," < 80 km. Each of these groups was divided into sub-groups, A and B types, $F-M$ giants, and $F-M$ dwarfs, and separate solutions were made for each group and sub-group, except the large velocity $A-B$ sub-group, which contained but three stars. Four small-velocity stars were omitted from the sub-groups because of doubtful classification but were subsequently assigned two to the $A-B$ and two to the dwarf sub-group. Three

*R. E. WILSON, unpublished investigation.

stars with abnormal space velocities were omitted. These are, respectively, O. Arg. S. 14818, 747 km., Lal. 28607, 706 km., and B. D. +19° 1185, 595 km. No other velocities exceed 400 km. The results of the solutions for the coördinates of the solar motion appear in Table I.

The *systematic motions* were determined by the method set forth by RAYMOND[8]. The corrections for perspective, distribution, and distance, described in sections 4 to 6 of his paper, were omitted as they do not apply to space velocities. Separate solutions were made as for solar motion, the results being shown in Table II.

TABLE I — SOLAR MOTION

		No.	A_0	D_0	V_0
			°	°	
Small V.	Giant	182	268.6	+18.4	20.0 km.
	Dwarf	187	274.9	+35.5	24.8
	A—B	72	262.4	+35.0	13.7
	All	445	270.3	+29.2	20.7
Large V.	Giant	18	278.1	+52.8	90.3
	Dwarf	51	304.5	+45.2	89.5
	All	72	297.5	+46.0	87.8

TABLE II

SYSTEMATIC MOTION

Small V.	A_1	D_1	λ_1	A_2	D_2	λ_2	A_3	D_3	λ_3
Giant	101°	+ 5°	517	5°	+19°	303	196°	+11°	181
Dwarf	89	+27	1171	273	+63	564	180	+ 2	348
$A - B$	98	+14	296	1	+28	92	212	+59	40
All	93	+18	758	319	+64	385	189	+18	262
Large V.									
Giant	88	+23	10834	348	+24	1817	216	+56	1175
Dwarf	83	+52	16761	288	+35	6383	189	+12	3082
All	86	+16	15293	298	+39	4529	191	+17	2617
A. J. 718									
Small μ	92	+ 4		353	+65		184	+25	
Large μ	92	+35		332	+36		212	+34	

The last two lines are derived from the proper-motions of the stars of the *Preliminary General Catalog*[8]. Certain tendencies, such as that of D_1 to be smaller; *i. e.*, galactic longitude larger; and of A_2 and D_2 to be larger for the small velocities than for the large, are seen to be common to both the proper-motions and real motions.

Three problems arising from these results require more than a mere passing notice. They are: (1) the trend of the V_0's in Table I, (2), the difference between the poles of preference derived from large and from small velocities in Table II: and (3) the relation of the λ's in Table II.

1. The progression of V_0 with the velocities of the stars would seem natural enough if we were dealing with proper-motions alone. Such a progression of M, the parallactic motion, is always found and is attributed to the greater mean parallax of the swifter moving stars. In other words, their high speeds are largely apparent only. Evidently no such explanation applies here. When the motions are examined in detail a marked tendency for the large velocities to favor a particular direction is seen[3]. (See Figure I.) This peculiarity in the motions of these stars was noted by Boss in 1918[7, 9] and, independently, by ADAMS and JOY in 1919[10]. The stars are found to be moving approximately toward a region of the Galaxy extending from galactic longitude 130° to 340°. OORT[11] finds the limits 130° to 342°. The fact that no stars of high velocity are moving toward points opposite this

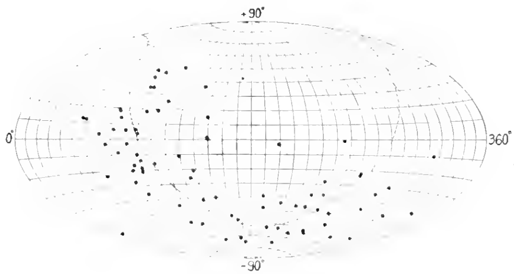

FIGURE 1

region renders it probable that we are dealing with a physical group and certainly accounts for the high velocity of the solar motion derived from such data. It is probable that the increase in the declination of the solar apex with decrease in apparent magnitude, noted by several investigators, is attributable to this cause, for in general the stars of fainter magnitude employed in the investigations are those with high space velocities. The group of high velocity stars is not similar to such groups as the *Taurus* cluster for it fans out, but the motions are entirely at variance with general stellar motions and demand further investigation.

As a matter of interest and partly to test the effect of a change in the value of the parallax upon the computed elements, a space velocity of 101 km. per second, suggested by CORLIN's high-velocity 61 *Cygni* group[12], was assumed for 62 of the high-velocity stars and the parallax of each star computed. A comparison of the Boss parallax, the latest Mt. Wilson spectrographic parallax, and that computed on this assumption is given in Table III. The numbers in the designation refer to the *Preliminary General Catalogue* and to *Cincinnati Publication No. 18*.

TABLE III

Star	Mag.	Spec.	Boss	Mt. W.	Hyp.	Star	Mag.	Spec.	Boss	Mt. W.	Hyp.
			"	"	"				"		"
130	4.5	G5	.032	.014	.031	2027C	6.7	K0	.066		.064
177C	8.0	F8	.026	.022	.022	3895	5.2	G0	.052	.046	.012
229C	7.9	G5	.022	.032	.025	3952	4.8	K0	.019	.042	.024
274C	6.9	G5	.009	.028	.028	2163C	6.0	G5	.021	.048	.034
500	5.4	K0	.007	.012	.015	2248C	6.8	G5	.086	.063	.082
388C	8.2	G5	.074	.032	.034	4342	7.9	K5p	.053	.100	.068
764	4.3	G5	.158		.165	4403	5.4	G0	.095	.105	.061
984	4.5	G5	.200	.219	.219	4638	3.4	K0	.045	.066	.040
709C	7.9	K0	.037	.048	.032	4656	3.9	K0	.018	.033	.016
1373	4.4	K0	.024	.028	.022	2420C	7.9	G5	.033	.033	.026
1627	6.0	G5	.010	.024	.013	4705	4.1	K0	.019	.020	.015
1783	4.2	K2	.022	.021	.009	4950	5.2	G5	.070	.095	.070
873C	7.7	G5	.017	.017	.026	4961	6.2	F8	.034	.035	.032
949C	6.9	G0	.053	.063	.047	4976	4.6	Ma	.018	.013	.011
2148	6.1	K2	.003	.008	.003	2554C	6.7	K0	.042	.100	.037
2247	3.5	G0	.002	.014	.006	5014	5.1	K0	.003	.021	.008
2712	2.6	K0	.002	.030	.020	2620C	7.2	K0	.067	.076	.069
2822	5.8	F8	.015	.012	.035	5180	5.7	K0	.064	.140	.059
2935	7.6	Mb	.415	.380	.378	2709C	7.9	G5	.027	.030	.028
2942	4.7	F0	.014	.017	.014	2728C	8.1	F8	.012	.014	.023
3069	6.3	G0	.028	.036	.023	2749C	7.3	F5	.044	.022	.044
1452C	8.0	G0	.018	.017	.026	2769C	6.5	G5	.043	.063	.036
3145	6.8	K0	.020	.023	.025	2885C	7.9	K0	.015	.024	.035
1522C	7.4	G0	.023	.033	.032	5790	4.9	K0	.020	.024	.017
1524C	7.9	G5	.033	.033	.025	5940	2.6	Ma	.005	.030	.010
3242	1.6	K0	.001	.017	.005	3014C	7.4	Map	.290		.285
3326	5.9	K0	.020	.016	.032	5984	4.5	K0	.015	.024	.015
1687C	6.9	G0	.024	.028	.033	5988	3.8	K0	.023	.022	.030
3662	0.2	K0	.087	.158	.095	3084C	6.8	K0	.014	.058	.043
3734	6.2	F8	.014	.025	.018	3085C	7.4	K0	.017	.021	.017
2024C	6.8	G5	.025	.033	.029	3145C	7.0	G0	.025	.035	.033

In general it is found that the computed parallax agrees well with the observed parallaxes, certainly as well as the two sets of observed parallaxes agree with each other. This suggest the possibility that the space velocities of many of these stars may be similar in size.

In order to study further the distribution of the large space velocities, the motions were transformed

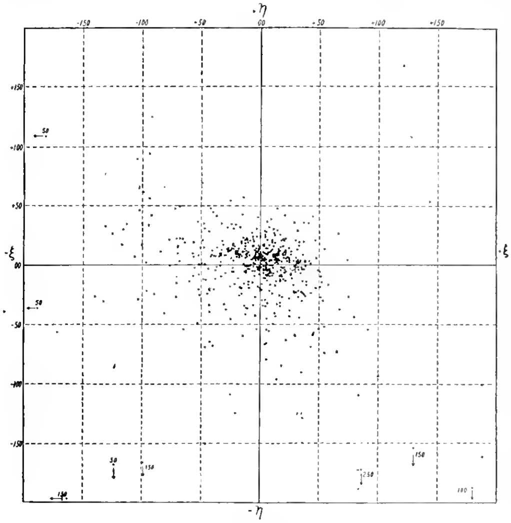

FIGURE 2

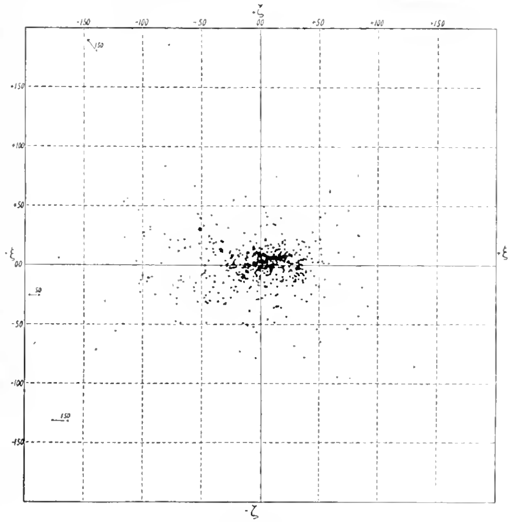

FIGURE 3

to a new set of axes, ξ directed toward the ascending node (190°.33, +27°.35), η toward 90° galactic longitude from the node, and ζ toward the north galactic pole. The equations of transformation are:

$$\xi = +.179\,x - .984\,y$$
$$\eta = +.452\,x + .082\,y + .888\,z$$
$$\zeta = -.874\,x - .159\,y + .459\,z$$

The scatter-diagrams of the velocities in the $\xi\eta$, $\xi\zeta$, and $\eta\zeta$ planes, respectively, are given in Figures 2, 3, and 4. Large negative values of both ξ and η are much more numerous than large positive values. We have essentially the same phenomenon found by STROMBERG[6, 13] in his bean-shaped velocity figures, by ADAMS and JOY[10], and, more recently, by OORT[11]. The large negative skewness, about equal in ξ and η, suggests the possibility of throwing the dissymetry into one coördinate by a rotation of these axes in their plane through 45°. The equations are:

$$\Xi = .707\,(\xi + \eta)$$
$$\mathrm{H} = .707\,(\eta - \xi)$$
$$\mathrm{Z} = \zeta$$

The coördinates of the assumed solar motions are in this system:

$$\Xi_0 = +18.8 \qquad \mathrm{H}_0 = +8.2 \qquad \mathrm{Z}_0 = +8.1$$

The distribution in these coördinates is given in TABLE IV, in which the seventh column gives the

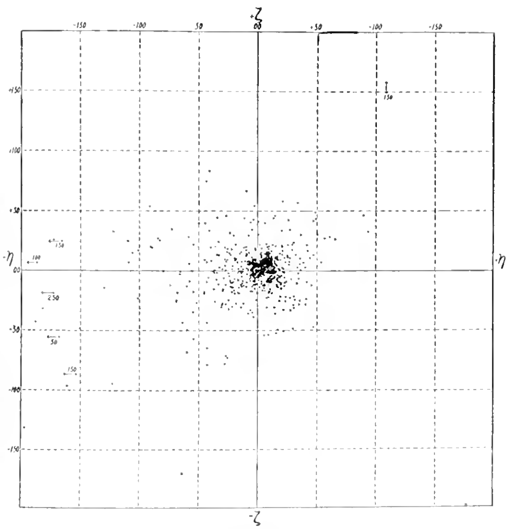

FIGURE 4

component of velocity in Ξ, H, or Z, rounded to the nearest multiple of 10. Columns 1 to 3 give the distribution for the 445 stars with $V < 80$, the columns 1 to 6 give the distribution for all 520 stars. The three rejected stars are bracketed.

TABLE IV. DISTRIBUTION OF MOTIONS

V<80			All Stars			km	Ξ			H			Z		
Ξ	H	Z	Ξ	H	Z		Df.	Gt.	A B	Df.	Gt.	A B	Df.	Gt.	A B
				1		+360				1					
					1	300							1		
				1	(1)	240				1			(1)		
				(1)	(1)	230					(1)			(1)	
				1		200				1					
				2		140				1	1				
				1		130				1					
				1		120					1				
				3		110				3					
				4		100				3		1			
				3		90				2	1				
				9	2	80				7	2		2		
1			1	3	1	70	1			3					1
1	11	1	3	11	2	60	3			9	2		2		
5	10	2	6	14	5	50	4	2		8	6		5		
6	13	8	7	13	10	40	2	5		9	4		8	2	
36	35	10	39	38	21	30	16	17	6	16	18	4	13	8	
63	51	34	64	55	41	20	17	29	18	23	26	6	19	20	2
94	61	117	95	62	122	+10	32	45	18	25	28	9	44	51	27
83	79	135	85	80	137	0	41	26	18	20	36	24	50	56	31
67	63	76	72	63	84	−10	30	32	10	17	28	18	41	31	12
31	51	27	36	54	34	20	20	13	3	24	20	10	19	13	2
27	21	21	31	25	29	30	21	9	1	11	9	5	15	12	2
16	22	1	21	23	6	40	15	5	1	17	6		4	2	
12	11	5	16	13	10	50	8	7	1	10	3		8	2	
3	5	2	8	7	3	60	6	2		5	2		3		
	6	1	8	10	3	70	5	2	1	9	1		3		
			6	2	2	80	4	2		1	1			2	
			5	1	2	90	4	1		1			2		
				3	1	100				2	1			1	
			1	1		110		1			1				
			2	1		120	2			1					
			1	1	1	130	1			1			1		
			2	1		140	2				1				
			2	1		150	1	1		1					
			1	1		160	1				1				
					(1)	170							(1)		
				1		180				1					
			1	1		190		1		1					
			2			210	2								
				1		250					1				
			1			290	1								
				1		310				1					
				1		330				1					
			1			360	1								
				(1)		380				(1)					
			(1)			390	(1)								
				(1)		470				(1)					
			(1)			560	(1)								
			(1)			−620		(1)							

The skewness is now practically confined to Ξ. Possibly a somewhat greater rotation, together with a slight tilt out of the galactic plane, would have accomplished this perfectly, but this transformation was considered sufficient for our purpose. The distributions of the H's and of the negative Ξ's resemble each other in showing a marked excess of very large and very small values with a corresponding lack of intermediate ones, while the distribution of the positive Ξ's is approximately Gaussian. The distribution likewise fans out toward the negative Ξ's (See Fig. 2), so that at Ξ = −35 the dispersion of H is about a half greater than at Ξ = 0. The dispersion of Ξ is about constant from H = +40 to H = −40. No Ξ exceeds +80, while the extension in the negative direction and that of H in both directions seems practically indefinite. The rejected stars have negative values of Ξ, but are divided in the other coördinates. They seem to be an integral part of the system of motions. If, however, we turn to the Z components, these three stars, with two others, (W. B. 17^h 514, $17^h 30^m$, $+6°.1$ and Arg. S. 20152, $20^h 18^m$, $-21°.7$), seem rather aberrant.

Most speculations upon the causes of the peculiarities in the distribution of stellar velocities have assumed forces which should apparently, bring about a distribution bilaterally symmetrical about each of the principal axes. Here is something quite different, and one can readily believe that the phenomenon has some relation to our eccentric position in the galactic cluster. It would seem more natural in that case, however, for the unsymmetrical axis to be directed radially to the galactic center; that is, to longitude 325° or the opposite[14]. On the contrary, that direction corresponds nearly to the H-axis. Perhaps the relation is to some more local center such as that of the *B*-type stars,[15] or the brightest part of GOULD's belt[16] near *Canis Major*, about 200°.

We are now in a position to see why the velocity of the solar motion comes out larger from the swift-moving than from the slow-moving stars. The skew axis is accidentally directed nearly, but not exactly, toward the antapex, and as larger and larger velocities are considered, larger and still larger proportions of stars moving in that direction are included, thus increasing the computed V_0 and slowly shifting the apex toward the +Ξ axis, that is toward higher declinations. This suggests that determinations of V_0 might be more stable if measured from the mode of stellar velocities instead of from their mean. Unfortunately, however, the determination of the mode is not easy without large numbers of stars. This phenomenon bids us be cautious in applying the principle that the parallactic motion derived from proper-motions is proportional to the mean parallax.

2. The solution of the second difficulty follows at once. If we should draw a surface whose height above the ΞH plane should at every point be proportional to the number of velocity-points whose projections fall at that point, the highest part of the surface would lie in a ridge whose axis would have a longitude of about 180° − 360°. This is equivalent to saying that the smallest velocities show preferential motion in that direction. This modal ridge would be very steep toward the *plus* direction of the Ξ axis, 45°, coming rapidly down to the plane, but in the other directions it would spread out asymptotically in a broad "skirt" from near 135° throughout 225° to 315° or more. As V's are included up to larger and larger limits, the major axis of the total distribution is rotated toward the axis of H, since there additions at both ends of that axis but only at the negative end of the Ξ axis. For the smallest range of velocities which it is practicable to handle, the process has already begun, and we get vertices in longitudes about 160° or 170°, while for the largest range it is practically complete, giving longitudes about 135°. As the solar motion is at the same time rotated toward the Ξ axis, the apex and vertex, starting from about 135° apart, become more and more nearly at right angles to each other. This angle is exhibited in the following table.

TABLE V

DISTANCE FROM APEX TO VERTEX

Present paper	small V's	133°	large V's	81°
Proper-motions[8]	small μ's	135	large μ's	112
SCHWARZSCHILD's method[17]	small μ's	135	large μ's	123
Real motions[4]	giant	145	dwarf	122
COMSTOCK faint stars[18]				87

Evidently the relation between giant and dwarf stars, between bright and faint stars and between early and late types, is of the same character as that between stars with large and small velocities. It becomes a matter of interest to examine the velocities with a view to ascertain, if possible, which of these relations is primary. For this purpose the counts of Ξ and H according to the three groupings *A* and *B*, giant, and dwarf were made and tabulated in the second part of Table IV. These counts were also made for Z though the range in that coördinate is smaller and the effect of its peculiarities on the geometry of the problem less striking. A brief inspection of the table will

show that the characteristic distribution for the whole material holds for the giants and dwarfs separately, and probably also for A and B, though here the material is weak. On the other hand the whole scale of giant motion is smaller than that of dwarf motion, while that of A and B is yet smaller. In other words, these groups are similar in skewness, though different in dispersion.

3. The determinations of the axes of stellar motion from proper-motions have pretty unanimously placed the least axis near the galactic pole, while those based upon radial velocities have almost as uniformly found the intermediate axis in this position and the least axis in or near the galaxy. The real motions agree with the proper-motion results, as they did in an earlier paper by Boss[4]. It must be borne in mind, however, that the three classes of determinations are not based upon quite the same stars; the radial velocities are far scantier than the proper-motions and contain a larger percentage of giant stars, while the supply of real motions is meager indeed. In view of the persistent systematic differences between, say, spectral types, it would be rather surprising if the motions should prove to be completely uncorrelated to those factors which determine whether or not a star shall have its parallax measured, whether its radial velocity shall be determined or not. When, however, all the brighter stars have had their radial velocities and parallaxes measured, so that we have a large list with all the required elements, it will be possible to say whether differences such as are found between the radial and tangential motions arise simply because they are radial or tangential or because of the method of selecting the material; that is, whether the cause should be sought in the geometry of the motions or in the physical state of the stars. It will suffice to point out that, if the velocity figure were greater, though of the same form for the stars outside the galaxy than for those within it, the difference in question would be inevitably produced, and the proper-motions and real motions would agree against the radial velocities.

As a test of this possibility the stars were divided into two groups: galactic stars (G) within 30° of the galactic plane, and non-galactic stars (Ng) outside these limits. Among the small motions, the galactic half of the sky contains 60% of the giant and $A-B$ stars and 47% of the dwarfs; among the large motions these percentages are 54 and 50, respectively. Solutions for the solar and systematic motions give the following results:

TABLE VI

Group	No.	A_0	D_0	V_0	A_1	D_1	A_2	D_2	A_3	D_3	λ_1	λ_2	λ_3
			°		°	°	°	°	°	°			
>80 G	10	305	+45	98	86	+49	283	+39	186	+ 9	15766	6831	2732
>80 Ng	32	285	+17	77	88	+42	307	+42	197	+20	12520	3663	1669
<80 G	243	276	+34	19.5	104	+17	335	+12	200	+19	632	381	231
<80 Ng	202	264	+23	22.4	84	+20	279	+65	176	+ 5	879	402	267

Certain contrasts between galactic and non-galactic stars appear, but as some of these are of opposite directions in the slow and swift-moving stars and all are less than the contrasts dependent on the size of the motions, very little can be concluded. The velocity figure for the slower stars seems to be larger outside the galaxy than within it, but not enough larger to explain the interchange of the second and third axes in the radial velocity determinations and this relation is reversed in the large velocity groups. The distribution of velocities is almost identical in galactic and non-galactic stars; in particular, the skewness is practically the same. It can be said, however, that the velocity figure of the non-galactic stars is more elongated and flattened than that of the galactic stars.

The small motions of the "super-giants" and of the stars of very early type must have suggested to many astronomers a relationship of some sort. Hertzsprung[19] has recently suggested that the "white" stars represent the next step in the evolution of the bright, "yellow" stars, or super-giants of middle types. It, therefore, seemed worth while to examine the characteristics of the motions of the stars brighter than 0.0 magnitude. There are 81 of these stars in our list, 78 of which have velocities less than 80 km. per second. They were divided into three groups, $B-A$, $F-G$ and $K-M$. The $B-A$ group was further subdivided into B and A, $B8$ and $B9$ being placed in the A group. The material was further reduced by taking only those stars brighter than

-1.0, -1.5, and -2.0, successively. Solar motion was derived as follows:

TABLE VII

Type	No.	A	D	V
B	8	263°	+27	25
A	13	262	+47	13
$B-A$	21	266	+36	17
$F-G$	20	271	+31	21
$K-M$	37	275	+22	13
$B-M$	78	271	+27	21
< -1.0	29	282	+26	25
< -1.5	11	269	+17	23
< -2.0	6	273	+16	23

Such agreement is possible only because of the small peculiar velocities of these stars and because of the fact that, dealing as we are with real motions, our results are affected by anomalies of distance and distribution only insofar as they impair the reliability of our data. Even so the accordance is surprising enough.

The systematic motion of the 78 stars is as follows:

TABLE VIII

Pole	A	D	λ
Preference	103°	+ 4°	432
Intermediate	7	+44	162
Avoidance	191	+47	77

The velocity figure has the small D_1 and easterly A_1 and A_2 characteristic both of early types and of very bright stars.

The motions of the three omitted high-velocity stars are, in the Ξ H Z system, (-194, $+143$, -26), (-70, $+94$, -49) and (-33, -27, -79), and their absolute magnitudes are -0.4, -0.1, and -0.1. The spectrum of one is Fo and of the others Ko. They show the same trend as the other high-velocity stars. The other 78 are distributed as shown in Tables IX and X. It will be seen that the resemblance to the $B-A$ stars of all magnitudes (Table IV) is much closer than to the giant $F-M$ stars. (The latter group contains 57 of these stars and the former only 21, about proportional to their total numbers.) This resemblance remains even when the three stars not in Table V are included. As we turn from dwarf stars through giants to supergiants we pass from high to low and lower peculiar velocities and dispersions, but still find the skewness in Ξ which seems to be characteristic of all available stars of all velocities and absolute magnitudes and of all the common spectral types, and which in its extreme manifestation appears as the tendency of high velocities toward the third galactic quadrant.

SUMMARY

1. The space motions of 520 stars give values for the solar motion which agree with those derived from proper-motions in placing the apex farther north for the swiftly-moving stars. The amount of motion is greater also for the swift than for the slower stars.

2. They agree with the proper-motion results in giving a velocity-figure flattened toward the galaxy and elongated in the direction of the constellations

TABLE IX

Motions of Supergiants, By Types

Ξ	B	A	B-A	F-G	K-M	B-M	H	B	A	B-A	F-G	K-M	B-M	Z	B	A	B-A	F-G	K-M	B-M
+40	.	.	.		..	..	+40		.		.	2	2	+40					.	..
30	.	1	1	.	1	2	30	1	.	1	1	4	6	30	.				2	2
20	.	4	4	4	5	13	20		2	2	3	4	9	20	.	.			3	3
10	2	2	4	6	14	24	10	1	2	3	3	8	14	10	.	2	2	9	9	20
0	3	3	6	4	3	13	0	4	4	8	5	11	24	0	5	8	13	9	14	36
10	2	2	4	4	6	14	10	2	1	3	6	5	14	10	3	3	6	1	7	14
20	1	.	1	.	4	5	20		2	2	1	1	4	20	.		..	.	1	1
30	.	1	1	.	2	3	30	.	2	2	.	..	2	30	.	.	..	1	1	2
40	.	.	.	1	1	2	40	.		.	1	1	2	40	.	.	..	.	..	
50	.		.	1		1	50	.				.		50			..			
−60	.	.	.	.	1	1	−60	.				1	1	−60	.		..			

TABLE X

MOTIONS OF SUPERGIANTS. BY ABSOLUTE MAGNITUDES

	Brighter than					Brighter than					Brighter than			
	2	1.5	1	0	y	2	1.5	1	0	z	−2	1.5	1	0
+40					+40			1	2	+40				
30				2	30		1	3	6	30			1	2
20		1	2	13	20	1	1	3	9	20			1	3
10	5	7	13	21	10	3	1	5	11	10	2	3	9	20
0	1	1	3	13	0	1	3	10	21	0	3	7	13	36
10		1	1	11	−10	1	2	1	11	10	1	1	5	11
20		1	3	5	20			1	4	20				1
30			2	3	30				2	30				2
40			1	2	40			2	2	40				
50				1	50					50				
60			1	1	−50				1	−60				

Lacerta and *Sagittarius*, with a tendency for the *Auriga* vertex to lie farther north for the large velocities.

3. The large space velocities show a strong tendency toward the region comprised within galactic longitudes 130° to 340°. Slight modifications in the parallaxes would group them still more closely.

4. The distribution of the space velocities shows a marked skewness, the axis of greatest skewness lying in about longitude 225°.

5. The first three phenomena are shown to be expressible in terms of the fourth.

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THE PROPER-MOTIONS AND MEAN PARALLAX OF THE *CEPHEID* VARIABLES.

BY RALPH E. WILSON.

The use of the proper-motions of the *Cepheid* variables as the determining factor in modern estimates of the size of our stellar system considerably enhances the importance of deriving, as soon as is consistent with accuracy, the motions of as many as possible of these stars. From the comparison of the magnitudes of special classes of stars in the globular clusters with those outside, SHAPLEY was led in 1918[1] to the conclusion that the diameter of the stellar system must be at least 300,000 light years, or ten times as large as earlier investigators had indicated it to be. One of the most fundamental points in his deductions seems to be in the determination of the zero-point of his scale from the proper-motions of but eleven *Cepheid* variables. His conclusions have been subject to attack by CURTIS[2], KAPTEYN and VAN RHIJN[3] and others, who hold that his parallaxes should be increased seven or eight fold. The problem is so complicated by the questions arising from the inclusion or rejection of data that the judgment of the astronomical world has been held somewhat in abeyance pending the collection of additional material.

With these considerations in mind the writer has made a survey of all the meridian-circle data available for the *Cepheids* and for a number of other variables of unknown type and period whose spectra suggest *Cepheid* variation. The data includes both the San Luis 1910–11 and Albany 1908–17 unpublished observations. The survey has resulted in the determination of new proper-motions, reduced to the system of Boss' *Preliminary General Catalog*, of 73 stars. To these have been added 10 stars with periods less than one day whose proper-motions were determined by KAPTEYN and VAN RHIJN[3] and one with proper-motion by TUCKER[4], making 84 in all. These stars are listed in Table I, the respective columns of which give the following data:

1 List number.
2 Star and Constellation.
3 Right-ascension for 1900.
4 Declination for 1900.
5 Median visual magnitude.
6 Draper Classification of spectra.*
7 Period*.
8 Galactic latitude.
9 Parallax from the period-luminosity curve.
10 Proper-motion in right-ascension in time.
11 Same in arc.
12 Probable error of same.
13 Proper-motion in declination.
14 Probable error of same.
15 Total proper-motion.
16 Weight of same on the following system:

pe.	wt	No.
< ″.010	1.0	58
″.010 – .015	0.8	9
.015 – .025	0.5	13
> .025	0.2	4

These weights were also assigned to τ.

17 λ = Distance from star to apex of solar motion.
18 τ-component of proper-motion.
19 υ-component of proper-motion.
20 Parallactic motion.
21 Weight of same = wt. by (16) × $\sin^2 \lambda$.
22 Period-group and rejections. The reasons for the rejections are given below the table.

*The more recent photometric data, together with the classification of spectra from 19 to 0 hours of right-ascension, were supplied by the Harvard College Observatory. Apparently all of these spectral classes vary.

TABLE I

Star	α 1900	δ 1900	Mag.	Sp.	Period	b	π_s	μ_α			μ_δ		μ	wt	λ	τ	υ	υ sin λ	wt	G
	h m	° ′			d	°	″	s	″	″	″	″	″		°	″	″	″		
1 *SU And*	0 18.4	+28 51	9.3		0.442	−33	.0012	.0007	−.009	±.013	−.004	±.010	.010	0.8	80	+.008	−.006	−.006	.77	I
2 *TU Cas*	20.9	+50 44	7.9	F2	2.137	−11	.0015	+39	+.037	18	−.071	32	.080	0.2	70	+.050	+.063	+.067	.18	II
3 *RX Cep*	1 2.0	+81 25	7.6	G0	130	+19		81	−.018	01	.006	09	.019	1.0	62	+.011	−.015	−.017	.78	R
4 *α UMi*	1 22.6	+88 46	2.1	F8	3.968	+26	.0160	+.138:	+.046	01	+.001	01	.046	1.0	60	−.018	+.043	+.049	.76	II
5 *RR Cet*	27.0	+0 45	8.6		0.553	−59	.0046		+.011	01	−.068	01	.069	1.0	108	+.052	+.046	+.049	.90	I
6 *U Tri*	49.7	+33 16	11.6		0.447	−27	.0004		+.021	06	−.010	06	.023*	1.0	93	−.005	+.022	+.022	1.00	I
7 *SU Cas*	2 43.0	+68 28	5.9	F5	1.950	9	.0038	+.0021	+.012	01	.006	02	.011	1.0	75	−.005	+.012	+.012	.93	II
8 *SZ Tau*	4 31.4	+18 20	7.1	G0	3.149	−17	.0018	+12	+.017	07	−.014	08	.022	1.0	127	−.009	+.020	+.025	.64	II
9 *RX Eri*	47.2	−15 54	9.2		0.587	−32	.0012	+00	±.000	26	+.064	24	.064	0.2	158	−.047	−.043	−.114	.07	I
10 *SU Aur*	49.6	+30 21	8.7		0.470	−7	.0016	+19	+.025	10	.034	11	.042	0.8	117	−.014	+.039	+.044	.63	I
11 *RX Aur*	54.5	+39 49	7.6	G0p	11.626	+0	.0006	27	.034	17	±.000	22	.031	0.5	109	+.030	−.008	−.008	.45	II
12 *SS Gem*	6 2.5	+22 38	8.8	G5	14.87	+2	.0002	06	.008	12	+.002	12	.008	0.8	127	+.008	−.002	−.003	.51	R
13 *T Mon*	19.8	+7 8	6.2	G5p	27.012	−1	.0007	20	−.030	08	+.004	08	.030	1.0	143	+.031	±.000	±.000	.37	II
14 *RT Aur*	22.1	+30 34	5.3	G0	3.728	+11	.0038	+14	+.014	03	−.020	02	.024	1.0	119	−.016	+.021	+.024	.76	II
15 *W Gem*	29.2	+15 24	7.1	G5	7.916	+5	.0010	+01	+.004	08	.010	08	.010	1.0	134	−.003	+.010	+.014	.52	II
16 *ζ Gem*	58.2	+20 43	4.0	G0p	10.154	+13	.0036	04	−.006	01	−.009	01	.010	1.0	127	+.004	+.010	+.013	.63	II
17 *RU Cam*	7 10.9	+69 52	8.4	K0	22.17	+29	.0002	+71	+.037	06	−.009	21	.038	0.5	79	−.039	−.001	−.001	.48	II
18 *U Mon*	26.0	−9 34	7.4	G5	56 :	+5	.0004	14	−.024	08	−.017	08	.027	1.0	151	+.005	+.027	+.056	.23	R
19 *X Pup*	28.5	−20 42	8.5	K0	25.953	+0	.0002	+06	+.008	17	+.036	17	.037	0.5	158	+.027	−.025	−.067	.07	II
20 *RS Pup*	8 9.2	−34 17	7.4	K0	41.31	±0	.0003	20	−.025	18	−.003	20	.025	0.5	152	−.003	+.025	+.054	.11	R
21 *V Car*	26.7	−59 47	7.8	G5	6.695	−12	.0009	08	−.006	09	−.017	08	.018	1.0	114	−.017	−.005	−.008	.39	II
22 *RZ Vel*	33.6	−43 46	7.0	K0		+0		31	.033	06	+.004	06	.033	1.0	146	−.006	+.032	+.058	.30	R
23 *T Vel*	34.4	−47 1	8.0	G5	4.639	−3	.0010	+23	+.023	15	.017	14	.029	0.8	146	−.010	−.027	−.048	.25	II
24 *SX Vel*	44.5	−45 58	8.4	G5		2		21	.022	07	+.002	08	.022	1.0	145	−.003	+.021	+.037	.33	R
25 *V Vel*	9 19.2	−55 32	7.8	G5	4.371	+1	.0012	+01	+.003	14	−.027	14	.027	0.8	138	−.025	−.010	−.015	.38	II
26 *l Car*	42.5	−62 3	4.3	G0	35.523	7	.0013	24	.017	02	+.012	03	.021	1.0	132	+.007	+.019	+.026	.55	II
27 *UX Car*	10 25.4	−57 6	8.2	F2	3.682	+1	.0010	18	.039	09	−.010	15	.040	0.8	127	−.011	+.039	+.049	.51	II
28 *VY Car*	40.6	−57 2	7.3	G5	18.981	+2	.0005	+11	+.036	09	−.031	16	.047	0.5	126	−.032	−.035	−.044	.32	II
29 *U Car*	53.7	−59 12	7.4	G0	38.740	+0	.0003	+00	±.000	09	+.001	07	.001	1.0	124	+.001	±.000	±.000	.69	II
30 +58 3216	11 5.4	+58 18	7.4	F8		+1		13	.010	05	−.010	07	.014	1.0	112	−.009	+.011	+.013	.71	R
31 *SU Dra*	32.2	+67 53	9.2	A2	0.660	49	.0012	10	.006	05	−.131	17	.131	0.5	65	−.122	+.017	+.052	.41	I
32 *S Mus*	12 7.4	−69 36	6.8	F8p	9.657	7	.0010	28	−.015	08	−.014	08	.019	1.0	147	−.014	+.018	+.020	.80	II
33 *T Cru*	15.9	−61 44	7.2	G0	6.732	+1	.0012	26	−.018	10	±.000	07	.018	1.0	114	+.006	+.017	+.019	.84	II
34 *R Cru*	18.4	−61 4	7.3	F5	5.825	+1	.0012	+04	+.003	05	−.017	08	.017	1.0	114	−.017	+.002	+.002	.84	II
35 *R Mus*	36.0	−68 52	7.0	G5	0.882	7	.0030	+03	+.002	03	−.008	07	.008	1.0	115	−.009	+.001	+.001	.82	I
36 *S Cru*	48.4	−57 53	7.0	G0	4.690	+1	.0016	53	−.012	05	−.013	07	.014	1.0	109	+.007	+.014	+.017	.89	II
37 *W Vir*	13 20.9	−2 52	9.6	Pec	17.271	+57	.0004	54	.084	10	+.019	09	.083	1.0	71	+.059	+.058	+.060	.93	R
38 *XX Cen*	33.8	−57 6	7.4	G5		+3		25	.020	05	−.010	07	.022	1.0	103	+.003	+.022	+.023	.95	R
39 *RU CVn*	55.4	+32 7	11.4		0.364	+73	.0005		.022	06	−.008	06	.023*	0.5	51	−.002	+.023	+.030	.31	I
40 *W CVn*	14 2.2	+38 18	10.3		0.552	+70	.0007		.039	06	.015	06	.042*	1.0	18	−.009	+.041	+.055	.56	I
41 *ST Vir*	22.5	−0 27	10.8		0.411	+53	.0006		+.008	04	−.016	04	.018*	1.0	60	−.018	+.003	+.004	.75	I
42 *V Cen*	25.4	−56 27	7.4	F5	5.494	+3	.0014	33	.027	05	−.018	07	.032	1.0	98	+.006	+.032	+.032	.98	II
43 *RS Boo*	29.3	+32 12	10.3		0.377	+66	.0008		+.011	05	.008	05	.014*	1.0	44	−.011	−.009	−.013	.49	I
44 *RY Boo*	45.2	+23 27	7.2	F7	9.0	+62	.0009	+37	−.051	07	.014	07	.052	1.0	44	−.027	−.044	−.061	.18	R
45 *R TrA*	15 10.8	−66 8	7.0	F5	3.389	9	.0018	12	.007	08	−.025	07	.026	1.0	101	−.009	+.024	+.024	.96	II
46 *RW CrB*	35.3	+29 56	9.6	F8	0.726	70	.0010	63	.082	21	−.016	19	.084	0.5	31	−.003	+.081	+.161	.14	I
47 *S TrA*	52.2	−63 30	6.9	G5	6.323	9	.0014	08	.005	14	.008	08	.009	1.0	97	±.000	+.009	+.009	.98	II
48 *U TrA*	58.4	−62 38	8.4	F5	2.568	9	.0013	+55	−.038	08	±.000	17	.038	0.5	96	−.034	−.017	−.017	.50	II
49 *S Nor*	16 10.6	−57 39	7.4	G0p	9.752	7	.0009	+04	+.003	04	.009	06	.009	1.0	90	−.007	+.007	+.007	1.00	II
50 *TZ Her*	31.4	+38 44	8.8	F5		+11		20	.021	16	−.008	21	.025	0.5	20	.015	+.021	+.061	.06	R
51 *RV Sco*	51.8	−33 27	7.4	F5	6.062	+1	.0013	03	.004	10	.028	11	.028	0.8	66	−.004	+.028	+.031	.66	II
52 +26 11880	59.9	+26 27	6.8	G5		7		+00	±.000	05	+.003	05	.003	1.0	58	+.001	−.003	.004	.72	R
53 *ST Oph*	17 28.8	−1 4	11.6		0.450	15	.0004		.008	04	+.005	04	.009*	1.0	32	+.009	−.003	−.006	.29	I
54 *X Sgr*	41.3	−27 48	4.7	F8	7.012	+1	.0035	05	.007	02	−.017	02	.018	1.0	58	+.006	+.018	+.021	.72	II
55 *RY Sco*	44.3	−33 40	8.2	G5	20.32	+4	.0003	+13	+.016	08	−.017	09	.023	1.0	64	−.015	−.018	−.020	.80	II
56 *Y Oph*	47.3	−6 7	6.3	G0p	17.121	+8	.0009	+00	±.000	08	.003	08	.003	1.0	37	±.000	+.003	+.005	.36	II
57 *W Sgr*	58.6	−29 35	4.7	F8p	7.594	−5	.0033	+07	+.009	03	.007	03	.011	1.0	60	−.009	+.007	+.008	.74	II

	Star	α (1900)	δ (1900)	Mag.	Spec.	Period	b	π_s	μ_α			μ_δ		μ	wt.	λ	τ	υ	υ sin λ	wt.	G
		h m	° ′			d	°	″	s	″	″	″	″	″		°	″	″	″		
58	*AP Sgr*	18 7.0	−23 9	7.3	F5	10.8	−3	.0008	−.0007	−.010	±.006	−.011	±.008	.015	1.0	53	+.010	+.011	+.014	.64	II
59	*Y Sgr*	15.5	−18 54	5.8	F8p	5.773	−1	.0024	+ 15	+.021	08	−.005	06	.022	1.0	49	−.021	+.007	+.009	.57	II
60	*XX Sgr*	19.0	−16 51	9.0	G5	6.43	−1	.0005	+ 05	+.007	34	−.060	34	.060	0.2	17	−.004	+.061	+.083	.11	II
61	*U Sgr*	26.0	−19 12	6.9	F8	6.745	−6	.0013	− 06	−.009	01	−.007	01	.011	1.0	50	+.010	+.006	+.008	.58	II
62	*RU Sct*	36.7	−4 13	8.9	G5	20.3	−1	.0002	− 11	−.016	27	−.015	27	.022	0.2	35	+.020	+.011	+.019	.07	II
63	*YZ Sgr*	13.7	−16 50	7.4	G5p	9.553	−8	.0008	+ 19	+.027	15	.005	13	.027	0.5	48	−.026	+.011	+.015	.28	II
64	*BB Sgr*	45.1	−20 24	7.5	G0	6.8	−10	.0010	+ 09	+.013	06	−.047	05	.049	1.0	52	−.003	+.049	+.063	.61	II
65	*κ Pav*	46.6	−67 21	4.5	F5p	9.092	−26	.0032	− 04	.002	02	+.017	05	.017	1.0	98	−.004	−.017	−.017	.98	II
66	*SZ Aql*	59.6	+1 9	8.7	K2	17.136	−3	.0003	− 15	−.022	13	−.010	13	.024	0.8	32	+.024	±.000	±.000	.22	II
67	*TT Aql*	19 3.2	+1 9	7.6	G5	13.753	−5	.0006	− 02	−.003	06	−.015	06	.015	1.0	32	+.010	+.012	+.022	.29	II
68	*RR Lyr*	22.3	+42 36	7.2	F5	0.567	+12	.0030	−106	.117	01	−.190	06	.223	1.0	21	+.104	−.198	−.561	.12	I
69	*U Aql*	24.0	−7 15	6.6	F8p	7.024	−13	.0014	+ 03	+.004	07	−.003	07	.005	1.0	12	−.003	+.005	+.007	.45	II
70	*XZ Cyg*	30.4	+56 10	9.7		0.467	+16	.0010	+127	+.106		−.042		114†	0.8	31	+.107	+.037	+.070	.26	I
71	*U Vul*	32.3	+20 7	7.0	G5	7.990	−2	.0011	− 04	−.006	07	−.030	07	.031	1.0	23	+.029	+.010	+.025	.16	II
72	*SU Cyg*	40.8	+29 1	6.6	F5	3.846	+2	.0021	− 15	−.020	07	−.010	07	.024	1.0	22	+.013	−.018	−.048	.18	II
73	*η Aql*	47.1	+0 45	4.0	G0p	7.176	−11	.0046	+ 05	+.008	02	.011	02	.013	1.0	39	+.001	+.014	+.022	.39	II
74	*S Sge*	51.5	+16 22	5.8	G0p	8.382	−7	.0018	+ 02	+.003	03	−.005	03	.006	1.0	29	+.002	+.006	+.012	.24	II
75	*R Sge*	20 9.5	+16 25	9.4	Cont	70.56	−11	.0001	− 07	−.010	05	−.020	05	.021	1.0	32	+.022	+.001	+.002	.29	R
76	*SZ Cyg*	29.6	+46 16	9.2	K0	15.113	+3	.0002	+ 78	+.081	17	−.014	22	.082	0.5	33	+.035	+.082	+.149	.15	II
77	*V Vul*	32.3	+26 15	9.0		37.79	−8	.0002	− 22	−.030	09	−.004	08	.030	1.0	34	+.009	−.029	−.052	.31	R
78	*X Cyg*	39.5	+35 14	6.5	G0p	16.385	−5	.0008	− 11	−.013	07	.012	05	.018	1.0	33	+.013	−.012	−.022	.30	II
79	*T Vul*	47.2	+27 52	5.8	F8p	4.436	−11	.0028	± 00	±.000	05	±.000	04	.000	1.0	37	±.000	±.000	±.000	.36	II
80	*SW Aqr*	21 10.2	−0 20	10.4		0.459	−33	.0007		−.053	04	−.039	04	.066*	1.0	54	+.064	−.016	−.020	.67	I
81	*β Cep*	27.4	+70 7	3.3	B1	0.190	+14	.0180	+ 37	+.019	01	+.003	01	.019	1.0	49	+.005	+.018	+.024	.57	I
82	*SX Aqr*	31.1	+2 47	11.8		0.536	35	.0004		+.005	04	−.027	04	.027	1.0	57	+.019	+.020	+.023	.71	I
83	*δ Cep*	22 25.4	+57 54	4.1	G0	5.366	+1	.0054	+ 14	+.011	01	+.002	01	.011	1.0	53	−.002	+.011	+.014	.64	II
84	*RZ Cep*	35.7	+64 20	9.4	A2	0.309	+6	.0012		+.082	14	+.179	14	.197	0.5	54	.172	+.092	+.114	.32	I

Rejections

3, 12, 18, 20 and 75. Periods over 40 days.

22, 24, 30, 38 and 50. Period and type of variation unknown.

37. Bright lines in spectrum, large radial velocity and high galactic latitude.

44. Period uncertain, high galactic latitude. *Cepheid?*

52. Period unknown. Miss Cannon says this is a *Cepheid*.

77. Period uncertain. *Cepheid?*

The Proper-Motions

An examination of Column 15 of the table shows but one star, *RR Lyræ*, with a proper-motion exceeding 20″, but two exceeding 15″, and but four exceeding 10″ per century. The periods of these four stars are 0.66, 0.57, 0.47 and 0.31 days. It is generally conceded that there are two classes of *Cepheids*, one with periods less than a day which we call the cluster-type and the other with periods in general greater than two days, the former being much the more numerous in the clusters and the latter outside. The fact that all the large proper-motions in Table I belong to stars of the cluster-type would immediately suggest a dissimilarity in the motions of the two classes of stars. When we divide the data into the two groups, rejecting all questionable cases and stars with periods over 40 days, the *Cepheid* character of all of these being questioned, we get the following mean values:

Group	No.	Mag.	Per.	b	μ	τ	q
I	19	9.77	0.52	35	″.0565	+″.0079	+″.0169
II	51	6.77	10.53	7	.0218	− .0009	+ .0132

Several points of dissimilarity appear. Eleven of the 19 cluster-type stars have galactic latitudes greater than 30°; all of the 51 stars of Group II have galactic latitudes less than 30°, the average without regard to sign being 7°. Low galactic latitude seems to be a peculiarity of the longer period *Cepheids*. The average proper-motion of the stars of Group I is over 2.5 times that of Group II, the largest reliable proper-motion — weight 1.0 or 0.8 — of a star of that group being less than 5″ per century. The large mean τ of Group I suggests large peculiar motion and, similarly, the small τ of Group II in comparison with the relatively large parallactic motion, q, is suggestive of small peculiar motion. It appears, therefore, that we have to deal with two dissimilar groups of stars, one scat-

*Proper-motion by Kapteyn and van Rhijn[3].
†Proper-motion by Tucker[4].

tered more or less at random over the sky and having a wide range both in magnitude and peculiar motion, the other lying close to the Galaxy with a more moderate range in magnitude and exceptionally small peculiar motion.

It is proposed to determine the mean parallaxes of these two groups of stars from a proper combination of the parallaxes derived from their parallactic and peculiar motions. The parallactic motion may be derived from the proper-motions in two ways: from a solution for the coördinates of the solar motion, or from the ν-component of the proper-motion directly by the formula[1]

$$q = \Sigma\, \nu \sin \lambda / \Sigma \sin^2 \lambda,$$

where λ is the distance from the star to the apex of solar motion. If sufficient homogeneous data is available, the two methods should give the same results, granting of course that the group of stars have no large systematic drift. When, however, but a few proper-motions are available and these decidedly unhomogeneous, as in the case of the stars of Group I, the second method should give definitely more reliable results inasmuch as it is free from uncertainty in the direction of the solar motion. The position of the apex referred to the stars of Group I is uncertain to the extent of 90° at least, depending upon the treatment of the material, so the mean parallactic motion derived from these solutions is of little value. In the case of the stars of Group II, as will be shown later, the mean parallactic motions derived by the two methods are essentially the same. As, however, further subdivision of the data makes solutions for the coördinates of the solar motion impracticable, we propose to use for both groups the parallactic motion derived by the second method.

TABLE II

DEPENDENCE ON PROBABLE ERROR

pe	No.	μ	τ	wt.	q	wt
< ″.005	11	″.016	″.0063	11.0	+ ″.0135	9.28
″.005 – .010	22	.020	.0108	22.0	+ .0148	13.22
.010 – .015	5	.037	.0131	1.0	+ .0134	2.02
> .015	10	.015	.0310	4.1	+ .0012	2.61
< .015	41	.0195	.0096	40.0	+ .0142	24.52
< .010	36	.0181	.0090	36.0	+ .0143	22.50

In an earlier paper attention was called to a decrease in average proper-motion with increasing accuracy in the determinations. While such an effect might not be noticeable to any great extent in the determination of the mean parallactic motion, it should show up definitely in the average τ taken without regard to sign, providing only that we are dealing with fairly homogeneous data. In Table II is shown the dependence of the data for the stars of Group II upon the probable error of the proper-motion.

The increase of both μ and τ with the probable error is definite. There is no evidence of such dependence in the case of q but the wide range and the presence of several negative values in the group with probable errors greater than ″.015 indicate a considerable degree of uncertainty. It is evident that, if we use proper-motions with large probable errors, we introduce into our average peculiar motions, even when the individual values are weighted, errors which give falsely large mean values and also decrease considerably the accuracy of the determinations of the mean parallactic motion. The investigations of SHAPLEY and of KAPTEYN and VAN RHIJN were based upon proper-motions with probable errors less than ″.010. The means for the 36 stars with this degree of accuracy are given in the last line of the table. In view of the essential agreement of the values of q and the slow increase of the τ up to that point, however, it was decided to base the further investigations of this paper upon the proper-motions with probable errors less than ″.015, giving the final results also for the stars with probable errors less than ″.010. Excluding, then, the proper-motions with probable errors greater than ″.015 there remain 11 stars in Group I and 41 stars in Group II.

TABLE III

DEPENDENCE ON MAGNITUDE

GROUP I

Mag.	No.	μ	τ	wt.	q	wt.
< 10.0	11	″.083	″.0532	8.1	+ ″.0209	5.03
> 10.0	8	.029	.0180	7.5	+ .0126	4.78

GROUP II

Mag.	No.	μ	τ	wt.	q	wt.
< 5.0	8	.018	.0060	8.0	+ .0148	5.41
5.0 – 7.0	16	.018	.0108	16.0	+ .0139	8.85
> 7.0	17	.022	.0102	16.0	+ .0137	10.26
All	41	.0195	.0096	40.0	+ .0142	24.52

It has already been pointed out that the stars of Group I have a wide range in magnitude, while those of Group II do not. To determine the need of cor-

recting the proper-motions for the effect of magnitude an investigation was made, and the results are given in Table III.

For the stars of Group I there is a very evident need of the correction for magnitude and in the determination of the final means the proper-motions have been reduced to magnitude 10.0, the approximate mean magnitude of the group. For the stars of Group II there is no evidence of the magnitude effect. The slight decrease in the values of q in apparent only, as the shift of a single star in the grouping would make all three means essentially equal. Therefore, no magnitude correction has been applied to the proper-motions of Group II.

Inasmuch as in Group II we are dealing with homogeneous proper-motions of stars covering a small range of magnitude we should expect, if the period-luminosity relation is real, a decrease in the mean parallactic motion with period. In taking the final means a subdivision into period-groups was made so as to give three groups, at least, with approximately equal weight. The results for the different sub-groups and the final means for the two main groups are given in Table IV.

TABLE IV

MEAN PARALLACTIC AND PECULIAR MOTIONS

Group days	No.	Period days	Mag.	μ	τ	pe.	q	pe.
				″	″	″	″	″
0 – 1	14	0.49	9.33	.0565	.0250	±.0047	+.0149	±.0065
0 – 1	13*	0.55	10.61	.	.0274	.0049	+.0156	.0070
2 – 6	15	4.29	6.34	.0249	.0111	.0017	+.0201	.0037
6 – 9	13	7.41	6.41	.0173	.0072	.0015	+.0181	.0044
9 – 20	9	12.65	6.53	.0142	.0089	.0016	+.0046	.0040
20 – 40	4	30.40	6.52	.0188	.0135	.0044	–.0008	.0084
2 – 40	41	9.57	6.42	.0195	.0096	.0009	+.0112	.0022
2 – 40	36†	9.90	6.24	.0184	.0090	.0009	+.0143	.0021
2 – 20	37	6.31	6.44	.0196	.0092	.0008	+.0158	.0015
2 – 20	32†	6.80	5.81	.0183	.0084	.0008	+.0158	.0015

*Excluding β *Cephei*.
†Probable error of μ < ″.010.

The decrease in the parallactic motion with period for the stars of Group II is convincing. The decrease in the peculiar motion is not so evident but very little reliance can be placed in the mean derived from the four stars with periods from 20 to 40 days. They seem to have peculiar motions larger than should be expected for this class of star. The rejected proper-motions for stars of this sub-group show the same tendency. In order to do no violence to the data we have computed the final means both including and excluding these four stars. These means are given in the last four lines of the table. It is readily seen that there is very little difference in these determinations. The probable errors are reduced when we reject the periods greater than 20 days, but we lose thereby a certain amount of data which is valuable for extending later comparison with the period-luminosity curve. The use of the proper-motions with probable errors less than ″.010 slightly reduces the mean peculiar motion but has no effect upon the parallactic motion and, by cutting down the data lessens the reliability of the means. It is proposed, however, to carry thru determinations of mean parallax for all the groupings in Table IV.

It has been suggested that the application of a systematic correction to the Boss system of proper-motions in declination of the order indicated by KAPTEYN, +″.013 cos δ, would materially decrease the mean parallax derived from the proper-motions. In the case of the parallax derived from the parallatic motion, as will be shown later, this is quite true. It should be borne in mind, however, that SHAPLEY'S original system of parallaxes was based upon Boss' proper-motions. To arbitrarily reduce the proper-motions of this paper by a systematic correction which cannot be considered by any means as established and compare with proper-motions derived on the uncorrected system would manifestly be false procedure. If, on the other hand, a revision of the system of parallaxes is contemplated, KAPTEYN'S suggestion

must be given serious consideration. Consequently, it is of interest at this point, to see just how much a correction of this nature will affect the mean motions. It will have only a slight effect upon the motions of Group I, primarily because but five of the fourteen proper-motions used for this group are on the Boss system, the rest being determinations by KAPTEYN and VAN RHIJN and TUCKER, and, secondarily because the total motions are large. It will, however, enter with its full effect on the stars of Group II, for all the proper-motions are referred to the Boss system and are exceptionally small. This correction was suggested by KAPTEYN to account for the difference between the declination of the apex of solar motion derived from proper-motion and radial velocity data. The results of solutions for the coordinates of the solar motion referred to the 14 stars of Group II based upon the uncorrected and corrected proper-motions are given in Table V.

TABLE V

COORDINATES OF SOLAR MOTION

A	D	M	
°	°	"	
265.9	+55.6	.0137	uncorr. pms.
290.1	+ 1.6	.0070	pms. corr. by +".013 cos δ
278.	+30	.0101	pms. corr. by + .0065 cos δ
273.9	+52.7	.0142	81 stars, uncorr. pms.

From this tabulation it would appear that the application of a correction of the size suggested by KAPTEYN to small proper-motions greatly over-corrects, but that a correction half the size may ultimately be found necessary. The last line of Table V gives the coordinates of the solar motion derived from the 81 stars of Table I, rejecting none and making no reductions for magnitude. It is worthy of note that the parallactic motion derived from this solution happens to agree exactly with that derived from the 14 stars of Group II. (See Table IV.) For these same stars (the 14 stars of Group II) a correction of ".0065 cos δ to the proper-motions gives mean peculiar and parallactic motions of ".0094 and +".0101, against ".0096 and ".0142 in Table IV. It is evident, therefore, that should the need of such a correction be established, our mean parallactic motion for this group of stars would be subject to a reduction of about 30%. Inasmuch as no reduction in the mean peculiar motion is apparently produced by the correction, the total reduction in the computed mean parallax of the group would naturally depend upon the relative weights assigned to the two determinations. For a comparison with the existing system of parallaxes, as has been shown, no such correction is necessary or permissible.

THE RADIAL VELOCITIES

The radial velocities of *Cepheids* available to the writer are listed in Table VI. There is a considerable range in the relative accuracy of the determinations of the radial velocities but no system of weighting will materially alter the conclusions reached, so no weights have been used. As there are only six radial velocities

TABLE VI

RADIAL VELOCITIES

	Star	α	ρ	V
		h m	km	km
	Group I			
1	*SU Dra*	11 32.2	−202	−193
2	*SW Dra*	12 12.8	− 83	− 71
3	*RS Boo*	14 29.3	− 66	− 51
4	*RR Lyr*	19 22.3	− 69	− 50
5	*XZ Cyg*	19 30.4	−215	−196
6	*β Cep*	21 27.4	− 14	± 0
	Group II			
7	*TU Cas*	0 20.9	−23.:	−19.3
8	*α U Mi*	1 22.6	−17.	− 6.4
9	*SU Cas*	2 43.0	− 7.0	− 1.5
10	*SZ Tau*	4 31.4	− 3.2	−16.2
11	*T Mon*	6 19.8	+12.:	− 5.1
12	*RT Aur*	6 22.4	+21.4	+10.9
13	*ζ Gem*	6 58.2	+ 6.8	− 6.3
14	*l Car*	9 42.5	+ 4.0	−10.4
15	*S Mus*	12 7.4	+ 3.	− 6.7
16	*R Tr A*	15 10.8	−20.:	−21.3
17	*S Tr A*	15 52.2	+ 2.:	− 0.6
18	*S Nor*	16 10.6	− 8.	− 8.4
19	*RV Sco*	16 51.8	−28.:	−19.4
20	*X Sgr*	17 41.3	−13.5	− 2.4
21	*Y Oph*	17 47.3	− 5.0	+12.2
22	*W Sgr*	17 58.6	−28.6	−17.7
23	*Y Sgr*	18 15.5	+ 4.0	+18.4
24	*κ Pav*	18 46.6	+36.0	+33.2
25	*SU Cyg*	19 40.8	−35.8	−15.9
26	*η Aql*	19 47.4	−14.2	+ 2.5
27	*S Sge*	19 51.5	− 8.6	+10.2
28	*X Cyg*	20 39.5	+ 9.3	+27.3
29	*T Vul*	20 47.2	− 1.3	+16.0
30	*δ Cep*	22 25.4	−16.8	− 3.9

for stars of the cluster type, it is obviously useless to attempt to determine the coördinates of the solar motion with respect to these stars. The best we can do at present is to assume a value of the solar motion based on the observations of a large number of stars and try to take account of the uncertainty in the determinations of the mean parallax of the group. Assuming as the solar speed, 21.5 km. per second, which in the light of the more recent investigations is probably not in error by more than 1.0 km. for the stars in general, we derive the peculiar stellar velocity, V. The mean V for the six stars of Group I is 94 ±33 km. If we exclude *β Cephei*, $V = 113 \pm 35$ km.

The 24 radial velocities of stars of Group II are sufficient to give an approximate determination of the coördinates of the solar motion. The results of the solution for these coördinates are

$$A = 284^\circ.3, \quad D = +12^\circ.7 \quad V_0 = 21.4 \text{ km.}$$

If we combine the proper-motion and radial velocity results, we get as the general direction in which the *Sun* appears to be moving with respect to the *Cepheids* with periods greater than two days

$$A = 275^\circ.1 \qquad D = +34^\circ.2$$

The agreement of the value of V_0 derived from this solution with that derived from the stars in general lends justification to our proposal to use this value of the solar speed, $V_0 = 21.5$ km. per second*, in conjunction with the parallactic motion, for one determination of the mean parallax of this group of stars. Correcting the individual values of the radial velocities for this solar motion, we derive the mean peculiar motion of the stars of Group II, $V = 12.2 \pm 1.8$ km.

The Mean Parallax

If the proper-motions and radial velocities of a group of stars are known, the mean parallax of the group may be obtained both from the mean parallactic motion and from the average peculiar motion. The formulae are:

$$\pi_1 = 1.737\, \Sigma\, v \sin\lambda / V_0\, \Sigma \sin^2\lambda, \quad \pi^2 = 1.737\, \tau / V$$

If we assume that the value of the solar speed is 21.5 km. per sec., and let q represent the mean parallactic motion, the first equation becomes simply $\pi_1 = 0.220\, q$. The values of q and τ, with their probable errors are given in the last four columns of Table IV. The values of π_1 and π_2 for the same groups are given in the second and fourth columns of Table VII. If we were dealing with a large amount of data or with a more limited amount of homogeneous data, these two values should agree closely. When groups containing small numbers of stars are under consideration and their motions not well determined, we must expect large discordances and the problem becomes one of the proper combination to secure the most reliable results. The probable errors of π_1 and π_2 are given in the third and fifth columns of the table. They have been derived in two ways; first through multiplying the probable errors of the mean parallactic and peculiar motions by the factor used to obtain the parallax and, second, by means of the formulae given by RUSSELL[9].

$$r_1 = \pm .815\, \pi_1 V / V \sqrt{n\, \overline{\sin^2\lambda}}, \quad r_2 = \pm .721\, \pi_2 / \sqrt{n}$$

The two determinations of r_2 are essentially equal in every case. Where but a few stars are under consideration the two determinations of r_1 differ considerably, since the first determination is independent of and the second directly proportional to the parallax. In the absence of any criterion for estimating the relative value of the two, the mean has been used as the probable error of the parallax. The weights quoted in column 6 and used in the combination of the two sets of parallaxes are inversely proportional to the squares of these probable errors, but the coefficient is not 1.0. In Table III it was shown that, whereas the mean parallactic motion is apparently unaffected by the inclusion of weak proper-motion data, there is a direct dependence of τ upon the probable errors of the data, the mean value of τ for the data with probable errors from ″.010 to ″.015 being about twice that for the data with probable errors less than ″.005. In order to do justice to the data we must take account of this effect in some way. We have done this to a certain extent by giving the parallaxes determined from the parallactic motion, which appears to be independent of the probable error effect, double weight in comparison with those derived from the peculiar motions. The formulae for computing the weights thus become:

$$p_2 / p_1 = 0.5\, r^2_1 / r^2_2$$

*Derived by STROMBERG[6] from the radial velocities of 1400 stars of Classes *F* to *M*. It is probable that this value is too large. Recent investigations of the motions of the high-velocity stars reveal systematic motion in the direction opposite to the *Sun's* motion which produces a falsely large value of the solar speed when these stars are included in the solutions. From 1026 stars with space velocities less than 60 km. per sec. STROMBERG[7] gets 20.6 km. per sec. From 445 stars with trigonometric parallaxes greater than ″.005 and space velocities less than 80 km. per sec. Boss, RAYMOND and the writer[8] get 20.7 km. per sec. The use of these values for the solar speed would necessitate an increase in the computed parallaxes of about 4%.

TABLE VII

Mean Parallax

Group I

Period days	π_1	r_1	π_2	r_2	wt.	π_m	r	π_{sh}	f
	″	″	″	″		″		″	
0 – 1	+.00328	±.00268	+.00126	±.00024	5.9	.00155	±.00059	.00239	
	343	334	115	22	14.0	130	130	148	. .
			. .	. .	. .	142	62	159	0.88*
			. .		1.0	228		159	1.43†
	145		147		1.0	146	. .	159	0.92‡

Group II

Period days	π_1	r_1	π_2	r_2	wt.	π_m	r	π_{sh}	f
2 – 6	+.00442	.00080	+.00434	.00072	0.62	.00438	.00077	.00315	1.39
6 – 9	+ 398	86	279	57	1.14	335	71	183	1.83
9 – 20	+ 101	56	345	72	0.30	158	60	134	1.18
20 – 40	– 018	96	524	180	0.14	048	106	065	0.74
2 – 40	+.00312	.00041	+.00372	.00038	0.58	.00334	.00040	.00212	1.58
2 – 40	315	40	349	38	0.55	327	39	225	1.45
2 – 20	348	36	357	37	0.47	351	36	228	1.54
2 – 20	348	38	326	36	0.56	340	37	245	1.42

*Computed weights π_2 relative to π_1 used.
†Equal weights, π_1 and π_2.
‡Solar motion of 50 km. per second assumed.

None of the determinations of probable error take into account the uncertainties in the determinations of the mean peculiar motions. In the case of the stars of Group II, perhaps, there is little reason for concern, as the probable error of the mean peculiar motion is not a great deal larger than the possible error in the determination of the solar velocity. In the case of the stars of Group I, however, it has been shown that the uncertainty in the mean peculiar motion amounts to one-third the total motion. The minimum account which might be taken of this uncertainty would be to divide the weight given by the formula by nine. This has been done for the stars of Group I. These must be considered as the maximum weights which π_2 may have relative to π_1.

The great difference between π_1 and π_2 for Group I is due to the fact that, regardless of the question of probable error, we have not even a very approximate idea of either the solar speed with respect to these stars nor of their peculiar motions. In the absence of this knowledge we have assumed, with Kapteyn and van Rhijn, that the solar motion from these stars is the same as that derived from the stars in general. It is well known that the solar speed derived from the more swiftly moving stars is in general appreciably greater than that derived from the more slowly moving ones, whence it becomes almost certain that, due to our assumption, the value of π_1 is too large. A solution from the six radial velocities available indicates a solar speed greater than 90 km. per sec. It is only necessary to assume a solar speed of 50 km., roughly, and compute the resulting peculiar motions to reduce π_1 and π_2 to equality. (See line 5, Table VII) It is interesting to note the close agreement of the mean parallax computed on this assumption with that derived by the use of the assigned weights. A reasonable increase in the solar motion with reference to these stars, then, would reduce π_1 and increase π_2 but would not materially alter the computed mean parallax.

On the other hand, it is quite probable that the few radial velocities now available for stars of this group are not representative. Of the six now known, one is 0 km., three are between 50 and 75 km. and two, approximately 200 km. While there can be little question that these stars have large peculiar velocities, it seems, especially in view of the comparative scarcity of velocities in excess of 100 km. for any class of stars, that the mean radial velocity of these stars is much more liable to be less than 75 km. than it is to be greater. A reduction in the mean radial velocity would

produce a reduction both in the mean peculiar motion of the stars and in the solar motion derived from them, with a consequent increase in the resulting parallaxes. This would not signify an increase in the π_1 given in the table, as this was computed from the assumed value of the solar motion, not that derived from the stars. No decrease to be reasonably expected in the mean radial velocity would give a value of π_1 as large as that quoted. The effect of a decrease in the mean radial velocity, therefore, would again be a decrease in π_1 and an increase in π_2 but the decrease in π_1 would be less and the increase in π_2 greater than that indicated in the preceding paragraph. The net effect upon the computed mean parallax would be a definite increase. The amount of that increase is, of course, at present indeterminate but it is reasonable to suppose that it would be of the order indicated by giving equal weight to π_1 and π_2. In view of the size of the motions of these stars it seems reasonable to assign this as the minimum weight which π_2 can have relative to π_1. This combination gives the results quoted in line 4, Table VII.

Throughout this discussion, as the reader will have noted, means for Group I have been taken with and without the data on *β Cephei*. The inclusion or exclusion of this star produces a considerable degree of uncertainty, as does the inclusion of any outstanding value in the mean of a small number of more accordant ones. There is some doubt as to the classification of *β Cephei* as a *Cepheid*. Its period is extremely short but this is possibly to be expected because of its spectrum, B1; its proper-motion is small but other small proper-motions are included in Group I; its radial velocity is small whereas the others in this group are large and its parallax derived from the period-luminosity curve is exceptionally large whereas the observed trigonometric parallaxes are small or negative. We have no reason sufficient for its rejection but its inclusion with full weight in the final means is not justifiable. In the final means, therefore, we have used *β Cephei* with half weight. By means of the weights in column 5, then, the two determinations of the parallax have been combined to give the concluded mean parallaxes in column 6. In column 8 are given the mean parallaxes for the same groups derived from the period-luminosity curve. In column 9 are given the factors by which the parallaxes in column 8 would have to be multiplied to obtain those in column 6.

With due consideration of the weakness of the data with which we have been dealing certain conclusions as to the mean parallax of the *Cepheids* are justifiable. We find no evidence from the proper-motions of a probable correction to SHAPLEY's parallaxes of either the short or long period *Cepheids* in excess of 40%, in direct opposition to the investigators who would demand an increase of seven or eight fold. The parallaxes derived by KAPTEYN and VAN RHIJN are unquestionably too large, due in part to their assumption of the solar speed. There is evidence of the possible need of a 40% increase in SHAPLEY's parallaxes, the evidence being direct in the case of the longer periods and indirect in that of the shorter periods. The *maximum correction* to these parallaxes indicated by the material under discussion, seems, therefore, to be *an increase* of 40%. The direct evidence from the stars of short periods indicates that SHAPLEY's parallaxes are essentially correct. It has been shown that, if a systematic correction of $''.0065 \cos \delta$ be applied to the proper-motions in declination given in this paper, the computed mean parallaxes of the longer period *Cepheids*, insofar as they are derived from the parallactic motion, would be reduced approximately 30%. Combination with the parallax derived from the peculiar motion would give a net reduction of approximately 20%, indicating but a slight possible increase in SHAPLEY's parallaxes. While the character and amount of such a correction to the proper-motions has not been established, the fact that systematic corrections of the right sign are found necessary to reduce nearly all the modern catalogs of position to the system of the *Preliminary General Catalog* may tend to substantiate its use in the revision of a system of parallaxes. From these considerations it would appear that the parallaxes derived from the period-luminosity curve cannot reasonably be decreased, nor on the other hand can they be increased more than 40%. In view of the uncertainties in the peculiar motions of the short period stars and the lack of determination in the suggested systematic corrections to the proper-motions, it seems that the most probable factorial correction to SHAPLEY's parallaxes must be nearer to 1.4 than to 1.0. Inasmuch as the factors in the last column of Table VII agree within the limits of their probable errors, we must conclude that no plausible evidence is found of an error in the slope of the period-luminosity curve. It may be justifiable, then, as a final step, to combine roughly the results for Groups I and II, in spite of the marked dissimilarity in their motions. From such a combination we get:

$$q = +''.0143, \qquad V_0 = 22.0 \text{ km.} \qquad \pi_1 = ''.00307$$
$$\tau = ''.0136, \qquad V = 28.6 \text{ km.} \qquad \pi_2 = ''.00226$$

Combining π_1 and π_2 by means of RUSSELL's formula

$$p_2/p_1 = 1.44\, V/V_0$$

we get π = ″.00254. Since π = ″.00199, f = 1.28.

From this and the considerations outlined above we conclude that the most *probable correction* to SHAPLEY'S parallaxes indicated by the data presented in this paper is an *increase of approximately* 30%.

The most pressing need for fixing the exact amount of the correction to the zero-point of the period-luminosity curve is the determination of the radial velocities of more of the short period *Cepheids*. Unfortunately all of these stars are faint and the observations can only be made with large instruments. In view, however, of the increased reliability which but a small number of additional radial velocities, even if they are only fair approximations, would give to the determination of the mean parallax of these stars, it is hoped that the observatories which have the facilities for this work may attempt to secure observations of some of them.

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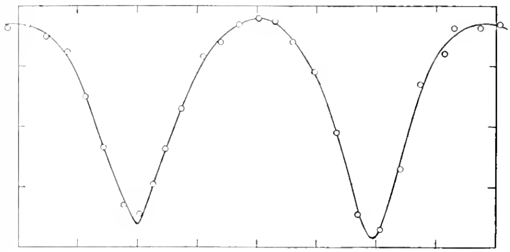
Dudley Observatory, Albany, N. Y.,
March 21, 1923.

AN ECLIPSING VARIABLE WITH AN UNUSUALLY SHORT PERIOD,

BY FRANK C. JORDAN

On the extra-focal plates taken with the 30-inch Thaw refractor for determining the light curve of the Cepheid variable *S Comae*, $\alpha = 12^h 27^m 48^s$, $\delta = +27° 31'.9$ (1900), I have found another faint variable in the approximate position, $\alpha = 12^h 28^m 1^s$, $\delta = +27° 16'.1$. Measurement and reduction of the plates has shown that this is an eclipsing variable with minima at intervals of $2^h 50^m.8$, or 0.1186 days. These minima, as far as can be determined by the limited number of observations already made, are of nearly the same depth, a plot of the curve using double the period given above showing a difference of less than one-tenth of a magnitude. This difference may be increased or it may disappear with further observations. The exposures have been 11 minutes in length and this tends to decrease the depth of the minimum as well as to make the observations uncertain in this part of the curve where the brightness is changing so rapidly. The total indicated variation in magnitude is about 0.73, from $11^M.24$ to $11^M.97$. There is no pause either at maximum or minimum. It was at first thought that *W Ursa Majoris* was an Algol variable with a period of about 4 hours, but the spectroscope showed that it must be considered a *β Lyrae* variable of 8 hours period with two equal minima. No existing spectroscope can cope with this new variable, so we can only reason from



analogy that its period is probably $5^h 41^m.6$, and it is therefore of the *β Lyrae* type. Further observations will be made with exposures of 2 or 3 minutes with the star much less out of focus than on the plates already obtained. A full discussion will be published later.

The figure shows the shape and approximately correct range of the light curve but in the absence of any photographic magnitudes for the comparison stars, and the consequent necessity of assuming a magnitude for one of them, the actual values of the maximum and minimum magnitudes may be considerably in error.

Allegheny Observatory,
April, 1923.

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OBSERVATIONS OF ASTEROIDS AT THE YERKES OBSERVATORY,

By G. VAN BIESBROECK, O. STRUVE and I. YAMAMOTO.

The following asteroids were measured on plates taken with the 24-inch reflector. Usually the plates were exposed for twenty minutes and taken in pairs in immediate succession. The moving objects could then be located by means of the blink-comparator. PAGET's "Hurricane" plates made it possible to reach beyond 16^m with the relatively short exposure of 20 minutes.

Only rough positions were obtained. The accuracy

KNOWN ASTEROIDS

	G. M. T. 1922	α (1925)	δ (1925)	Δα	Δδ	Mag.	Obs.
		h m	° ′	m	′		
99 *Dike*	Nov. 20.87	3 25.1	+23 54	+1.3	+16	14.9	Y
265 *Anna*	Sept. 16.73	23 52.3	+19 8	−0.1	0	16.0	S
275 *Sapientia*	Sept. 17.60	23 31.6	− 7 38	−0.4	− 7	13.5	S
320 *Katharina*	Sept. 16.67	21 57.1	+ 0 58	−0.6	− 3	14.2	S
320 *Katharina*	Sept. 20.60	21 55.2	+ 0 31	−0.1	− 2	14.9	S
394 *Arduina**	Dec. 21.51	6 35.3	+27 29	+0.2	+ 6	15.2	Y
756 1908 *DC*	Oct. 24.73	1 56.2	+10 56	−2.0	0	15.7	S
756 1908 *DC*	Oct. 25.72	1 55.4	+10 48	−2.1	0	15.7	S
756 1908 *DC*	Oct. 26.78	1 54.7	+10 39	−2.1	0	15.5	S
756 1908 *DC*	Oct. 29.82	1 52.7	+10 16	−2.0	0	15.5	S
784 1914 *UM*	Nov. 22.69	3 27.8	+30 25	+0.1	+ 2	14.2	VB
784 1914 *UM*	Nov. 23.72	3 26.9	+30 23	+0.1	+ 2	13.8	VB
810 *Atossa*	Dec. 21.87	missing					VB
810 *Atossa*	Dec. 22.79	missing					VB
907 *Rhoda*	Sept. 28.77	0 15.8	−21 5	−0.7	− 4	14.8	S
907 *Rhoda*	Oct. 17.72	23 58.6	−20 14	−0.7	− 1	14.9	S
907 *Rhoda*	Nov. 14.57	23 44.8	−18 4	−0.1	− 3	15.7	Y
907 *Rhoda*	Nov. 20.63	23 14.2	−17 15	−0.1	− 3	15.8	Y
933 1920 *GZ*	Nov. 22.82	4 6.3	+27 21	−0.3	− 3	13.8	VB
933 1920 *GZ*	Dec. 12.78	3 15.1	+27 45	−0.2	− 3	13.5	VB
954 1921 *JU*†	Nov. 23.79	3 12.3	+18 5	+2.5	+ 7	14.1	VB
954 1921 *JU*	Dec. 12.67	3 28.0	+17 18	+2.3	+ 8	13.7	S
955 1921 *JV*‡	Nov. 24.77	4 31.3	+36 51	−0.1	0	15.8	VB
955 1921 *JV*	Nov. 28.87	4 26.6	+36 46	−0.5	− 1	15.9	S
955 1921 *JV*	Dec. 1.97	4 23.0	+36 41	−0.5	+ 1	15.8	VB
955 1921 *JV*	Dec. 9.63	4 14.4	+36 21	−0.5	− 1	15.7	VB
955 1921 *JV*	Dec. 15.80	4 7.9	+36 1	−0.5	0	16.3	VB
955 1921 *JV*	Dec. 22.71	4 1.5	+35 31	−0.5	− 2	16.0	VB

* Correction to ephemeris in *Beob. Zirk.*, 30.
† Correction to ephemeris received from the Rechen-Institut.
‡ Correction to ephemeris in *Beob. Zirk.*, 25.

UNIDENTIFIED OBJECTS

Y. O. 1 (1922 NB)

G. M. T. 1922	α (1925)	δ (1925)	Mag.	Obs.
	h m s	° ′		
Oct. 24.731	2 1 38	+10 35.1	15.0	S
25.773	2 0 18	10 31.1	15.0	S
26.803	1 59 58	10 27.2	15.0	S
Oct. 29.849	1 57 35	10 16.1	15.1	S
Nov. 14.805	1 46 5	9 25.2	15.1	S
16.655	1 44 58	9 20.4	15.1	S
20.704	1 42 49	9 11.9	15.2	S
Nov. 22.732	1 41 49	9 7.9	15.7	S
Dec. 9.549	1 37 5	8 55.9	16.2	S
Dec. 12.585	1 36 55	8 57.3	15.9	S

Y. O. 2 (1922 NC)

Nov. 14.805	1 46 54	+ 9 39.9	15.7	S
16.655	1 45 37	9 43.4	16.0	S
20.704	1 43 19	9 51.5	15.7	S
Nov. 22.748	1 42 21	9 56.1	16.0	S

Y. O. 3 (1922 ND)

Nov. 14.805	1 45 31	+10 19.6	16.2	S
16.655	1 44 30	10 8.8		S
20.704	1 42 19	9 46.4	15.9	S
Nov. 22.748	1 41 21	9 35.8	16.0	S
Dec. 9.533	1 36 21	8 29.5	15.7	S
15.526	1 35 58	8 15.4	16.1	S
Dec. 20.668	1 36 12	8 7.4		S

Y. O. 4 (1922 NE)

Nov. 23.836	4 31 9	+36 29.4	16.0	VB
24.769	4 30 6	36 31.2	15.8	VB
Nov. 28.867	4 25 31	36 38.6	15.8	VB
Dec. 1.963	4 22 10	36 42.4	15.9	VB
9.627	4 13 32	36 44.8	16.0	VB
15.801	4 7 13	36 40.9	16.4	VB
Dec. 22.738	4 0 56	36 31.0	15.8	VB

Y. O. 5 (1922 MZ)

Nov. 23.836	4 37 18	+36 37.4	15.2	VB
Nov. 24.769	4 36 12	36 38.4	15.3	VB
Dec. 15.840	4 12 22	35 48.8	15.0	VB
Dec. 22.707	4 6 27	35 47.8	15.4	VB

Y. O. 6 (1922 MY)*

Nov. 24.783	4 32 38	+37 6.9	..	VB
Nov. 28.867	4 27 35	37 0.1	16.2	VB
Dec. 1.963	4 23 41	36 52.5	16.2	VB
9.627	4 14 23	36 22.8	16.0	VB
15.801	4 7 41	35 49.6	16.1	VB
Dec. 22.707	4 4 34	35 6.4	16.2	VB

* Observed Dec. 14 by M. Wolf, *Beob. Zirk.*, 34

is of the same order as that of the ephemerides published by the Rechen-Institut of Berlin. If desired, accurate positions could be deduced from the plates on request.

In the hope of extending our knowledge about the asteroids towards the ones that are fainter than the generally recorded ones, it is the intention of the observers henceforth to devote their attention to the fainter objects only, below 14^m, since the instrumental equipment used makes it possible to follow objects of 16^m and even fainter. The program includes the faint asteroids marked † in the "Oppositions Ephemeriden" for 1923, meaning that they are especially in need of measurement. The small size of the reflector's field — about $1\frac{3}{4}$ degrees on a side — will, of course, allow only those objects to be recorded for which the correction to the ephemeris is less than $\pm 3^m.5 \cos \delta$ and $\pm 52'$ since it would not be practical to cover a bigger area by a large number of plates. An object indicated as "missing" means that it has not been found within the above limits.

The preceding list hardly requires further explanation. Greenwich mean time is used. The positions are for 1925.0. The magnitudes are roughly estimated by comparison with a plate of the polar sequence. Unless otherwise indicated the corrections refer to the "Oppositions Ephemeriden 1922." The three observers are indicated by the initials VB, S and Y. The first part includes the objects where there is no doubt about the identity with known asteroids. The second list includes the objects, probably new, that have been measured on the same plates. Until further identified we will designate these by Y. O., followed by the order of discovery. Since it is unlikely that these faint objects are being observed elsewhere, we are trying to follow them as long as is necessary for establishing reliable elements. All of them are still under observation and circular orbits are used for extrapolating the positions. For these objects a few more accurate measurements are planned when the series are completed.

Williams Bay,
Jan. 9, 1923.

OBSERVATIONS OF THE SATELLITES OF *SATURN*, 1915-16,

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

BY ASAPH HALL.

[Communicated by CAPTAIN W. D. MACDOUGALL, U. S. Navy, Superintendent of U. S. Naval Observatory.]

Date	W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
				Mimas-Tethys				
	h m s	°	h m s	″				
1915 Nov. 9	14 14 37	286.41	14 22 48	14.66	4, 4	3-4	388, Brt.	First two p's with red wires.
27	13 36 25	87.28	13 38 10	77.41	4, 4	2-3	388, Brt.	*Mimas* faint.
Dec. 22	12 22 38	337.16	12 22 47	17.23	4, 4	2	367b, Red	
1916 Feb. 3	9 7 14	95.59	9 4 58	69.54	2, 2	3	367b, Red	
3	9 36 16	93.49	9 38 20	72.43	2, 2	3	367b, Red	
				Mimas-Rhea				
1915 Nov. 3	13 19 2	265.60	13 16 32	111.23	2, 2	2	367b, Brt.	
3	13 54 20	263.83	13 54 44	110.63	2, 2	2	367b, Brt.	
17	14 56 0	254.88	14 55 40	107.66	4, 4	2	367b, Brt.	Delayed by lights burning out.
Dec. 6	13 16 14	191.61	13 27 47	44.82	4, 4	2	367b, Brt.	First two p's with red wires.
				Rhea-Titan				
1915 Oct. 25	13 55 56	262.333	13 57 32	110.39	4, 4	3	390p, Brt.	
27	14 30 1	253.671	14 31 0	221.42	4, 4	4	390p, Brt.	
28	15 21 54	226.166	15 22 16	167.41	4, 4	3	390p, Brt.	
29	16 4 31	117.502	16 5 36	114.94	4, 4	3-4	390p, Brt.	
Nov. 9	15 6 40	280.023	15 9 24	220.64	4, 4	3-4	390p, Brt.	
10	12 54 34	263.435	13 7 59	284.02	4, 4	2-3	388, Brt.	
17	11 34 14	90.482	11 32 50	259.74	4, 4	3-4	390p, Brt.	
22	13 50 18	48.055	13 49 30	123.07	4, 4	2	390p, Brt.	
24	13 39 48	272.654	13 43 22	206.42	4, 4	2	390p, Brt.	
27	12 7 59	264.859	12 44 18	201.64	4, 4	2-3	388, Brt.	
30	13 4 56	137.114	13 5 42	122.38	4, 4	3	388, Brt.	
Dec. 2	12 0 22	112.774	11 54 57	81.12	4, 4	3	388, Brt.	Delayed by eyepiece fogging.
6	14 50 3	48.372	14 52 30	159.07	4, 4	2	388, Brt.	
15	10 48 23	236.082	10 55 49	92.99	4, 4	2-3	388, Brt.	Haze.
1916 Jan. 7	10 59 35	44.042	10 59 34	135.40	4, 4	3-4	388, Brt.	
8	10 27 38	350.362	10 27 3	64.67	4, 4	3	388, Brt.	
13	9 18 29	255.190	9 18 25	261.55	4, 4	3-4	388, Brt.	
18	8 21 2	139.388	8 22 14	147.42	4, 4	3-4	388, Brt.	Clouds.
26	9 57 55	283.936	..	.	3, 0	2	388, Brt.	Clouded.
Feb. 5	7 58 34	101.712	8 8 9	200.10	2, 3	2	388, Brt.	Haze. Clouds.
11	8 26 12	315.497	8 23 6	92.47	4, 4	3	388, Brt.	*Rhea* very faint at last. [Clouds.
Mar. 8	8 4 59	98.466	8 4 8	233.42	4, 4	3	388, Brt.	
16	8 47 23	262.291	8 45 47	252.98	4, 4	3	388, Brt.	
17	9 44 13	245.272	9 46 59	154.21	4, 4	3	388, Brt.	
25	8 39 19	89.624	8 40 19	121.75	4, 4	3	388, Brt.	
Apr. 10	9 59 6	74.534	10 0 10	234.22	4, 4	2-3	388, Brt.	

Date		W. M. T.	p	W. M. T.	s	Comp.	Seeing	Power and Illum.	Remarks
				Titan-Hyperion					
		h m s	°	h m s	″				
1915 Oct.	29	14 32 31	250.893	14 34 10	379.37	4 , 4	3-4	388, Red	Probably not *Hyperion*.
	30	14 29 38	260.693	14 36 26	148.66	4 , 7	2	367b, Red	*Hyperion* very faint.
Nov.	3	15 2 29	179.073	15 0 33	73.32	4 , 4	2-3	388, Red	
	17	14 1 56	266.742	14 3 22	426.98	4 , 4	2-3	388, Red	*Hyperion* faint.
Dec.	4	13 25 5	278.977	13 22 19	372.02	4 , 5	2-3	388, Red	Delayed by eyepiece fogging.
	8	13 25 35	214.768	13 30 22	278.77	4 , 5	2-3	367b, Red	
	9	12 5 38	230.086	. .	.	2 , 0		. . . . .	[fluctuating.
	10	14 18 20	200.060	14 17 14	132.46	4 , 4	2-3	367b, Red	Poor observation. Wires
1916 Jan.	3	14 26 21	250.687	14 26 45	164.19	4 , 4	2-3	367b Red	
	8	14 21 25	106.705	14 23 55	180.53	4 , 4	3	367b, Red	
Feb.	7	14 0 22	268.989	14 4 20	393.03	4 , 6	3	388, Red	First two p's with 367b.
Mar.	8	8 59 29	60.111	9 25 36	113.00	2 , 1	2-3	388, Red	Clouds.
	10	9 16 0	166.201	9 15 56	92.16	4 , 4	3	388, Red	Windy.
	23	8 31 0	273.434	8 31 16	394.94	4 , 6	2-3	388, Red	
				Titan-Japetus (p and s)					
1915 Oct.	25	15 2 35	264.875	15 3 0	337.17	4 , 4	3-4	388, Brt.	
	27	16 3 11	270.388	16 19 8	409.18	4 , 2	3-4	388, Brt.	
	30	15 47 3	267.867	15 48 51	610.52	4 , 4	3	388, Brt.	
Nov.	5	15 11 1	219.003	15 8 5	555.71	4 , 4	3	388, Brt.	
	9	13 45 50	223.297	13 45 27	188.25	4 , 4	3-4	388, Brt.	
	10	14 8 3	215.372	14 10 20	125.10	4 , 4	2-3	388, Brt.	Fogged eyepiece frequently.
	17	12 38 1	212.128	12 38 5	161.97	4 , 4	3	388, Brt.	
	22	12 29 25	119.228	12 32 4	285.02	4 , 4	2	388, Red	Moonlight. Haze.
	24	12 19 10	99.811	12 28 24	185.48	4 , 6	2	388 Red	
	30	14 59 13	78.553	14 56 26	541.94	4 , 4	3-4	388, Red	
Dec.	2	13 50 10	78.060	13 54 43	435.80	4 , 4	3	388, Red	
	9	14 13 19	86.991	14 14 40	681.96	4 , 4	3	388, Red	
	10	13 25 48	84.166	13 28 54	718.04	4 , 4	3	388, Brt.	
1916 Jan.	3	13 57 25	279.580	13 58 37	507.13	4 , 5	3-4	388, Brt.	
	7	12 37 38	262.249	12 42 6	620.63	4 , 6	3-4	388, Brt.	
	13	10 7 18	263.219	10 7 0	378.25	4 , 5	3-4	388, Brt.	
	18	8 56 57	265.843	. .	. . .	2 , 0	3-4	388, Brt.	Clouded.
	20	10 23 0	260.372	10 26 2	729.10	4 , 6	3	388, Brt.	
	26	9 6 10	227.814	9 8 6	320.63	4 , 4	2	388, Red	Haze. Clouds.
	31	8 50 34	168.869	9 0 18	52.29	2 , 2	. .	. . . .	
Mar.	9	8 29 30	16.665	8 30 38	122.67	4 , 4	2	388, Brt.	
	10	10 34 36	12.100	10 35 24	84.66	4 , 4	3	388, Red	Windy.
	16	10 18 54	11.898	10 45 54	151.50	4 , 4	3	388, Brt.	
	17	8 17 12	26.827	8 45 39	141.30	4 , 4	2-3	388, Brt.	
	23	10 7 20	276.757	10 6 39	512.83	4 , 4	3	388, Brt.	
	25	9 29 58	267.538	. .	.	2 , 0	3	388, Red	Too unsteady to finish.
Apr.	10	8 17 56	255.295	8 19 19	620.71	4 , 7	2-3	388, Brt.	

Titan-Japetus (transits)

Date	W. M. T.	$\Delta\alpha$	$\Delta\delta$	Comp.	Seeing	Power and Illum
1915 Nov. 5	$13^h\ 59^m\ 5^s$	$-37^s.554$	$-198''.85$	*t*19.10	2-3	367b Brt.

Seeing: 2 = good, 3 = fair, 4 = poor. Power and Illum: b = occulting bar over planet, p = prism, Brt. = bright field, Red = red wires.

Repsold micrometer was used. Value of one revolution = $20''.8347 + 0''.0000\ 22(t^\circ - 50^\circ F.) + 0''.0535$ ($0^{in.}.810$ — focal scale.)

U. S. Naval Observatory, Washington, D. C., 1923, Mar. 31.

VARIATION OF LATITUDE OBSERVATIONS AT THE U. S. NAVAL OBSERVATORY.

By F. B. LITTELL.

[COMMUNICATED BY CAPTAIN W. D. MACDOUGALL, U. S. NAVY, SUPERINTENDENT.]

The observers during the period 1922.0 – 1923.0 were F. B. Littell, J. D. Wise, and J. E. Willis. Practically all the plates were measured by Mr. Wise. The program was the same as heretofore. The star list has been changed by the substitution of 11 new stars in the list of 71 on account of some of the stars of the original list having been carried out of the field of the instrument by precession and on account of others having proved too faint for observation in average weather conditions.

The scale value was corrected by the results of the observations during the year. The probable error of a latitude from a single star for each year since the beginning of observations with the photographic zenith tube at the Naval Observatory is as follows:

	By individual stars	By seasons
1916	$\pm 0''.086$	$\pm 0''.098$
1917	.093	.090
1918	.086	.088
1919	.093	.096
1920	.098	.101
1921	.108	.108
1922	.109	.110

There has been a noticeable increase in the probable error as is evident from the table. Also the probable errors for the winter months are materially larger than for the summer months as is shown below. This results in the annual means being influenced slightly by the seasonal distribution of the observations and accounts for the difference between the yearly means when taken by individual stars and when taken by seasons. This seasonal difference points to the desirability of increasing the number of observations in the winter season to compensate for the decrease in accuracy at that time, but the prevailing conditions as to cloudiness are not favorable to that procedure. The average probable errors for each month as deduced from the observations of seven years are given below.

January	$\pm.105$	July	$\pm 0''.078$
February	.115	August	.080
March	.119	September	.085
April	.100	October	.086
May	.094	November	.108
June	.090	December	.110

There is also a variation in the size of the probable error dependent on the distance of the star from the middle of the plate. This seems to be due in part, at least, to an apparently temporary change in scale value for different nights, the observations being reduced with a constant scale value for considerable periods of time. The following are the average probable errors for different zenith distances as deduced from the observations of the year 1922.

Rev.	
0 to 20	$\pm 0''.100$
20 to 40	.105
40 to 60	.113

This element of the probable error may be expressed as ±0.0011 R where R is the number of revolutions measured. If these errors are actually due to a temporary change in the scale value, effective for a plate, their effect is almost entirely eliminated in the mean of each completely observed group by the symmetrical arrangement of the stars in each group with reference to the zenith.

Before April, 1919, all plates were dried quickly after developing by immersing them in pure alcohol, a method proposed and used by Dr. F. E. Ross, as a result of his experiments at Gaithersburg. About that time considerable trouble was experienced by a fogging of the plates which was apparently caused by the alcohol then procurable, although it was supposed to be pure. Its use was therefore discontinued. This course was the more readily decided upon, in view of the opinion of other authorities that ordinary drying would be just as satisfactory. The average probable error for 3 1-4 years before the change was ±0″.092 and for 3 3-4 years after the change it was ±0″.105. While the evidence is not conclusive, it appears that this may have been a contributory cause of the increase of the probable errors.

The quality of the images on the photographic plate which is estimated on a scale of 5 and is recorded by the plate measurer, does not seem to have any appreciable effect on the size of the probable errors.

The value of the constant of abberation deduced from the closing error for this year is 20″.485 ±0″.014, and the mean value for the seven years of this work is 20″.458 ±0″.0065.

Table 1 gives the variation of latitude at Washington for each twentieth of the year as deduced graphically from the adopted latitude curve.

TABLE 1

Corrections to Mean Latitude for Washington

1921.95	−0.″12	1922.50	+0″.12
1922.00	− .10	.55	+ .08
.05	− .08	.60	+ .04
.10	− .01	.65	+ .01
.15	+ .02	.70	− .02
.20	+ .09	.75	− .06
.25	+ .13	.80	− .10
.30	+ .15	.85	− .11
.35	+ .16	.90	− .13
.40	+ .17	.95	[− .15]
.45	+ .15	1923.00	[− .18]

Table 2 gives for each observing night, the designation of the observer, the number of stars observed and the resulting observed excess of the latitude of the instrument over +38° 55′ 16″.00 for each group, the mean for the night, and the correction "ν," to reduce the observed latitude to that given by the adopted curve.

TABLE 2

Observed Latitudes of the Photographic Zenith Tube

Date		Obsr.	No. Obs.		Observed Latitude +38° 55′ 16″.00+			ν
			ii	iii	ii	iii	Mean	
1922					″	″	″	″
Jan.	1.4	W	6	8	0.88	1.02	0.96	−.03
	2.4	L	8	5	0.71	0.93	0.81	+.12
	5.4	L	7	7	0.96	1.04	1.00	−.07
	6.4	W	7	1	0.89	0.69	0.87	+.06
	7.4	L	8	8	0.95	0.86	0.91	+.03
	12.4	L	8	8	0.89	1.00	0.95	−.01
	13.3	W	2		0.98		0.98	−.04
	14.4	L	8	8	0.85	0.94	0.90	+.04
			iii	iv	iii	iv	Mean	
	23.5	W	7	6	0.98	0.97	0.97	−.04
	24.5	L	8	7	0.89	0.89	0.89	+.07
	25.5	W	8	8	0.96	0.87	0.92	+.05
	26.5	L	8	7	0.94	1.03	0.98	−.01
	30.4	W	8	5	0.94	1.05	0.98	.00
Feb.	2.5	L	8	7	1.05	1.10	1.08	−.10
	3.5	W	8	8	0.97	1.05	1.01	−.02
	6.4	W	2		1.01		1.01	−.01
	7.4	L	8	2	1.02	0.76	0.97	+.03
	8.4	W	8	7	1.02	0.88	0.95	+.05
	13.4	W	3		0.85		0.85	+.17
	21.4	L	5		1.08		1.08	−.03
	22.4	W	7	8	1.05	1.12	1.09	−.04
	24.4	W	8	8	1.00	1.02	1.01	+.05
	25.4	L	6	1	1.02	1.35	1.07	−.01
	27.4	W	7	1	1.03	1.37	1.07	.00
	28.4	L	8	6	0.92	1.04	0.97	+.10
			iv	v	iv	v	Mean	
Mar.	5.5	L	8	8	1.16	1.04	1.10	−.04
	6.4	W	1		1.20		1.20	−.11
	8.5	WLW	8	7	1.03	1.20	1.11	−.01
	13.4	W	5		1.11		1.11	+.01
	15.5	W	6	8	1.12	1.22	1.18	−.06
	16.5	WL	8	8	1.04	1.08	1.06	+.06
	17.5	W	8	7	1.17	1.23	1.20	−.07
	22.5	W	8	8	1.15	1.15	1.15	−.01
	23.4	WL	5	6	1.19	1.11	1.15	−.01
	26.4	W	2		1.22		1.22	−.07
	29.4	WL	1		1.17		1.17	−.02
Apr.	1.3	W	2		1.49		1.49	−.33

Date		Obsr.	No. Obs.		Observed Latitude +38° 55′ 16″.00+			ν
1922					″	″	″	″
Apr.	2.4	W	8	7	1.14	1.12	1.13	+.03
	9.3	W	2		1.20		1.20	−.03
	10.3	W1	2		1.20		1.20	−.03
	11.4	W	6	3	1.21	1.30	1.21	−.07
	12.4	W	6	6	1.10	1.21	1.15	+.02
	15.4	W	6	8	1.26	1.18	1.22	−.04
	18.4	W	3	7	1.09	1.18	1.16	+.02
	20.4	W	5	8	1.11	1.04	1.07	+.11
			v	vi	v	vi	Mean	
	21.6	W1	4	7	1.19	1.14	1.16	+.02
	22.6	W	7	8	1.11	1.22	1.17	+.01
	24.6	W1	6	7	1.08	1.16	1.12	+.06
	29.5	W	8	6	1.12	1.31	1.20	−.01
May	1.5	W1	7	8	1.11	1.08	1.09	+.10
	7.5	W	8	8	1.29	1.32	1.30	−.10
	10.5	W1	7	8	1.26	1.30	1.28	−.08
	11.4	W	6		1.31		1.31	−.11
	19.5	W1	8	8	1.14	1.14	1.14	+.06
	22.5	W1	8	8	1.28	1.20	1.24	−.04
	23.5	W	7	7	1.22	1.20	1.21	−.01
	24.5	W1	8	8	1.12	1.15	1.14	+.06
	27.5	W1	3	8	1.29	1.22	1.24	−.04
	28.5	W	6	8	1.07	1.22	1.16	+.04
			vi	vii	vi	vii	Mean	
June	3.6	W	7	7	1.18	1.12	1.15	+.04
	7.5	W	8	4	1.25	1.24	1.25	−.06
	12.5	W	7	8	1.29	1.27	1.28	−.10
	15.5	W	8	5	1.12	1.12	1.12	+.06
	20.5	W	7		1.13	.	1.13	+.04
	21.5	W1	8	8	1.25	1.13	1.19	−.03
	22.5	W	8	7	1.11	1.03	1.09	+.07
	23.5	W1	7	8	1.23	1.19	1.21	−.05
	29.5	W	8	8	1.16	1.07	1.11	+.04
	30.4	W1	5		1.09		1.09	+.05
July	1.4	W	4		1.01		1.01	+.13
	5.5	W1	8	8	1.20	1.11	1.15	−.01
	6.5	W	8	7	1.18	1.11	1.15	−.02
	7.5	W1	7	8	1.21	1.16	1.18	−.05
	9.5	W	8	8	1.24	1.13	1.18	−.05
	11.5	W	8	8	1.22	1.06	1.14	−.01
			vii	viii	vii	viii	Mean	
	21.5	L	8	8	1.04	0.99	1.01	+.10
	22.5	W	8	8	1.08	1.05	1.06	+.05
	29.4	W	2		1.08	. .	1.08	+.01
	31.4	L	2		0.88	. . .	0.88	+.21
Aug.	2.5	L	8	8	1.06	1.06	1.06	+.02
	3.4	W	2		1.14	.	1.14	−.06
	4.5	W	6	7	1.20	1.15	1.17	−.09
	5.5	L	8	8	0.90	1.10	1.00	+.08
	6.5	W	7	8	1.11	1.17	1.14	−.06
Aug.	7.4	L	6		1.03		1.03	+.01
	9.5	W1	8	8	1.09	1.15	1.12	−.05
	14.4	W1	8	3	1.14	1.20	1.16	−.10
	15.5	L	8	8	1.02	0.99	1.00	+.06
	16.5	W1	5	8	0.96	1.02	1.00	+.06
	18.4	W1	8	8	1.04	1.01	1.03	+.02
	21.1	W1	6	8	1.06	0.96	1.00	+.05
	22.4	L	8	8	1.01	0.87	0.94	+.11
			viii	i	viii	i	Mean	
	23.5	W1	8	7	1.06	1.10	1.07	−.03
	28.5	W1	8	8	0.98	1.02	1.00	+.03
Sept.	4.4	L	1		1.21	.	1.21	−.18
	5.5	W	7	6	1.04	1.09	1.07	−.05
	9.4	W	7		1.00	.	1.00	+.02
	10.4	W	4	.	0.96	.	0.96	+.06
	13.5	L	8	8	0.97	1.04	1.00	+.01
	11.5	W	8	8	1.02	1.02	1.02	−.01
	16.5	W	8	7	0.96	1.03	1.00	.00
	19.4	W	1		1.16		1.16	−.16
	20.1	L	6		1.08		1.08	−.08
	21.5	W	7	7	1.05	1.04	1.05	−.06
	22.5	L	8	8	0.97	0.97	0.97	+.02
	23.5	W	8	7	1.02	1.11	1.06	−.07
	25.4	L	8	8	0.89	0.83	0.86	+.13
	26.4	W	8	8	0.98	0.97	0.97	+.01
	28.1	W	8	7	1.02	1.00	1.01	−.03
Oct.	2.4	L	8	7	1.00	1.01	1.01	−.05
			i	ii	i	ii	Mean	
	5.5	L	8	8	0.92	0.97	0.94	+.02
	11.5	L	8	8	0.85	0.92	0.89	+.05
	12.5	W	8	8	1.00	0.99	0.99	−.05
	17.4	W	5		0.89	. .	0.89	+.04
	18.5	L	8	8	0.88	0.85	0.87	+.06
	19.5	W	8	8	0.86	0.86	0.86	+.07
	20.5	L	8	8	0.89	0.93	0.91	+.02
	21.4	W	7		0.97	. .	0.97	−.01
	22.5	W	8	8	0.91	0.91	0.91	+.02
	24.5	W	8	8	0.79	0.97	0.88	+.01
	26.5	W	8	8	1.00	0.94	0.97	−.05
	30.5	L	8	8	0.98	0.92	0.95	−.03
Nov.	5.5	W	8	7	0.97	0.97	0.97	−.05
	9.4	W	8	8	0.95	0.98	0.97	−.05
	10.4	L	8	8	0.84	0.85	0.84	+.07
	15.4	L	8		0.91	.	0.91	.00
			ii	iii	ii	iii	Mean	
	16.5	W	8	8	0.80	0.83	0.82	+.09
	19.5	W	8	2	0.91	0.82	0.89	+.02
	21.5	W	8	8	0.88	0.99	0.93	−.03
	23.4	W	4		1.20		1.20	−.36
	25.4	W	6	.	1.03	.	1.03	−.13

Date		Obsr.	No. Obs.		Observed Latitude +38° 55′ 16″.00+			v
1922					″	″	″	″
Nov.	28.5	W	7	8	0.99	0.89	0.94	–.01
	29.5	L	8	7	0.85	0.85	0.85	+.01
	30.5	W	7	7	0.85	0.92	0.89	.00
Dec.	6.5	L	8	8	0.85	0.99	0.92	–.03
	10.5	W	8	8	0.99	0.80	0.90	–.02
	19.5	W	8	8	0.86	0.79	0.82	+.05
Dec.	21.5	W	8	7	0.88	0.82	0.85	+.01
1923	29.4	L	8	8	0.93	0.89	0.91	–.06
Jan.	5.3	W	1		0.83		0.83	...
	8.4	L	5	7	0.74	0.85	0.81	....
	10.3	L	6		0.79	.	0.79	....
	12.4	L	8	5	0.80	1.00	0.87	....

OBSERVATIONS OF ASTEROID [1922 W20] = (132) *AETHRA*,

MADE WITH THE PHOTOGRAPHIC TELESCOPE OF THE U. S. NAVAL OBSERVATORY,

By GEORGE H. PETERS.

[Communicated by CAPTAIN W. D. MACDOUGALL, U. S. Navy, Superintendent.]

Date		G.M.T.	Mag.	Astrographic 1925.0 α	Astrographic 1925.0 δ
1922		h m		h m s	° ′ ″
Dec.	22	16 00.6	9.5	5 42 58.54	+14 46 36.4
	23	14 58.0	9.5	5 41 12.46	+14 25 34.1
	24	15 36.0	9.5	5 40 24.31	+14 02 59.6
	26	14 43.0	9.5	5 37 47.14	+13 20 06.8
	29	15 01.9	9.5	5 33 55.90	+12 14 55.6
	29	15 40.9	9.5	5 33 53.70	+12 14 20.5
1923					
Jan.	5	15 13.0	9.5	5 25 39.44	+ 9 48 53.0
	8	14 13.0	9.5	5 22 36.43	+ 8 51 24.6
	9	14 38.0	9.8	5 21 37.00	+ 8 32 07.9
	13	13 44.1	10.0	5 18 07.42	+ 7 20 15.0
	13	15 14.0	10.0	5 18 04.18	+ 7 19 08.3
	19	14 05.5	10.5	5 14 02.35	+ 5 41 57.5
	22	14 11.0	10.5	5 12 35.50	+ 4 58 00.6
1923					
Jan.	24	13 26.0	10.8	5 11 51.91	+ 4 31 02.3
Feb.	8	12 03.0	11.0	5 12 02.09	+ 1 51 34.3
	14	13 53.0	11.5	5 14 50.78	+ 1 06 39.7
	16	13 35.0	11.5	5 16 05.46	+ 0 53 59.4
	19	12 47.0	12.0	5 18 14.06	+ 0 36 44.8
	21	13 02.0	12.0	5 19 52.20	+ 0 26 08.2
Mar.	8	12 25.0	12.0	5 36 23.88	– 0 32 47.0
	9	12 40.0	12.0	5 37 45.90	– 0 35 49.9
	14	12 35.0	12.0	5 44 56.21	– 0 49 32.9
	17	12 20.0	12.0	5 49 32.92	– 0 57 02.0
	20	12 13.0	12.0	5 54 24.06	– 1 04 08.9
	21	12 18.0		5 56 01.10	– 1 06 27.4
	24	12 27.0	12.0	6 01 14.23	– 1 13 19.0

Observations from Dec. 22, 1922 to Jan. 5, 1923 inclusive were published in *H. C. O. Bull.*, 782. They are reprinted here for convenient reference. Information of the previous observations at Algiers and Simeis had not been received here at that time.

In Jour., B. A. A. Vol. XXXIII No. 5, DR CROMMELIN announced, from computations by MESSRS. MERTON and CHAND, the identification of this object as the long lost Watson asteroid (132) *Aethra*. At the present epoch the asteroid is comparatively unperturbed.

The magnitudes given are eye estimates, except for the two observations of Dec. 29, where the brightness was carefully checked by comparison with several B. D. stars in the vicinity. Owing to a slight interference by clouds no estimate of magnitude was attempted on the plate of March 21. These reductions, from the plate measures, were computed by MISS E. A. LAMSON.

U. S. Naval Observatory,
May 7, 1923.

CONTENTS.

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Nos. 823

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MEASURES OF DOUBLE STARS.

By WILLIAM O. BEAL.

The following measures, made with the 10 1-2 inch refractor of the University of Minnesota, are a continuation of those published in the *Astronomical Journal* No. 737. Most of the stars measured were discovered by BURNHAM with his six inch telescope. The star places are for 1880.

B. G. C.	∗ Name	α	δ	1900+	θ	ρ	Mags.		Nights	Remarks
		h m	° ′		°	″				
52	β 254	0 5.2	+59 6	15.89	235.6	7.60	7.6	10.6	1	*A* and *B* (1)
				15.96	241.6	38.21	8.1	11.7	3	*A* and *C*
106	β 392	0 10.5	+60 52	16.89	69.3	20.26	6.0	11.9	1	
247	β 107	0 21.5	+62 41	17.84	113.8	151.96	10.3	9.9	3	*A* and *F* (2)
				17.84	92.5	45.39	10.3	11.8	3	*A* and *H*
292	β 108	0 27.7	+62 15	15.79	359.3	1.11	7.4	11.6	3	*A* and *B*
				17.91	360.9	3.77	7.6	10.3	1	*A* and *B*
				17.88	218.3	11.78	7.6	11.2	1	*A* and *F*
364	β 109	0 34.1	−17 10	17.93	351.5	101.97	8.2	10.7	3	*A* and *B*
				17.93	356.1	93.51	8.2	11.0	3	*A* and *C*
395	β 231	0 38.0	+47 38	16.15	303.0	33.09	5.5	11.6	1	
440	β 232	0 43.6	+49 59	15.92	294.2	27.79	8.1	10.1	3	*AB* and *C*
455	β 1	0 45.8	+55 58	16.28	82.1	1.48	8.3	10.7	3	*A* and *B*
				16.07	135.5	3.66	8.2	8.9	5	*A* and *C*
				16.08	194.6	9.06	8.2	9.6	5	*A* and D
				16.22	331.5	15.53	8.3	11.7	1	*A* and *E*
614	β 235	1 3.5	+50 22	16.42	98.8	1.02	7.6	7.8	1	*A* and *a* (3)
				16.01	286.8	42.98	7.2	10.1	3	*A* and *B*
				16.01	67.8	60.57	7.2	10.0	1	*A* and *C*
				16.23	48.3	7.73	10.1	11.2	1	*C* and *c*
633	β 236	1 5.1	+46 21	15.80	143.5	5.18	8.3	8.6	1	
662	β 3	1 9.6	+55 52	15.80	26.0	1.17	8.0	10.1	1	
758	β 82	1 20.5	+44 17	16.88	110.7	122.26	5.2	10.9	3	*A* and *C* (4)
				16.88	138.4	5.15	10.9	11.0	3	*C* and *D*
990	β 259	1 46.3	−10 19	15.92	235.9	1.51	8.5	10.8	3	
992	β 260	1 46.8	+44 51	16.38	241.8	1.03	8.3	8.7	4	(3)
995	β 183	1 47.4	−17 20	15.86	227.1	2.59	8.0	9.3	4	
1409	β 261	2 38.5	−28 25	16.86	96.1	2.71	8.1	10.2	2	*A* and *B*
				16.87	131.1	70.15	7.9	10.0	3	*A* and *C*
1418	β 9	2 39.7	+35 3	16.88	172.0	1.90	6.4	9.2	2	(5)
1424	β 262	2 40.6	+30 33	16.08	60.9	1.63	8.1	10.5	5	

B. G. C.	✶ Name	α	δ	1900 +	θ	ρ	Mags.		Nights	Remarks
		h m	° ′		°	″				
1127	Σ 305	2 10.7	+18 52	18.06	311.2	3.13	6.9	7.8	5	
1160	β 10	2 11.1	− 5 29	16.55	100.5	2.39	7.7	10.9	3	
1512	Σ 333	2 52.1	+20 52	18.06	203.7	1.28	6.0	6.6	6	(6)
1913	β 85	3 48.6	+17 17	15.99	211.1	1.33	8.0	10.5	3	
2159	741	4 16.5	26 1	17.83	10.7	15.11	6.9	8.0	5	*A* and *D*
2167	β 102	4 17.0	1 33	17.52	71.0	7.50	9.2	11.5	2	*A* and *B*
2287	β 88	4 31.6	2 13	16.23	87.7	31.72	5.5	11.7	5	
2639	β 188	5 11.8	6 58	18.17	251.1	31.65	3.9	11.7	5	*A* and *B*
				18.17	59.7	36.36		11.1	5	*A* and *D*
2670	β 189	5 11.6	5 28	16.13	283.8	1.22	7.5	11.9	3	
2673	β 190	5 11.6	8 9	16.08	1.2	35.11	8.1	8.6	1	*AB* and *C*
2701	β 191	5 17.3	+31 27	16.11	23.9	3.71	10.2	10.3	3	
2857	β 90	5 30.9	+30 25	16.09	269.1	12.55	6.1	8.7	3	*AB* and *C*
				16.09	112.9	33.23	6.1	11.1	3	*AB* and *D*
2968	β 192	5 40.9	+39 8	16.19	353.3	39.67	5.3	11.6	3	*A* and *B*
				16.19	31.2	19.61	5.3	10.9	3	*A* and *C* (2)
3008	β 91	5 44.2	14 31	16.10	175.9	2.76	6.1	9.9	3	
	A C	5 50.0	+10 32	18.19	192.6	22.60	9.1	9.1	5	
3271	β 96	6 10.5	+ 9 59	16.25	257.1	63.05	6.2	11.1	3	*A* and *B*
				16.25	159.2	119.11	6.2	9.9	3	*A* and *C*
				16.25	225.9	1.60	9.9	11.6	3	*C* and *D*
3596	*Sirius*	6 39.9	16 31	18.23	70.3	11.13		9.9	3	(7)
	Espin 340	6 58.8	+31 52	18.22	138.5	5.15	9.2	9.7	5	
1060	β 198	7 20.6	20 13	17.22	211.1	5.86	8.0	11.1	3	(1)
1122	*Castor*	7 27.0	+32 9	18.20	217.0	5.31	2.2	3.1	6	*A* and *B* (8)
				18.20	161.1	73.25	2.0	10.0	5	*A* and *C*
1161	β 200	7 30.7	+35 49	16.28	190.6	100.92	5.5	10.8	3	*A* and *B* (2)
				16.27	99.3	161.40	5.5	10.0	4	*A* and *C*
				16.31	211.3	1.67	10.6	11.5	2	*C* and *D*
1192	β 201	7 33.7	−20 0	16.12	332.8	2.95	7.9	8.5	3	
	Espin 901	7 35.3	+51 29	18.02	130.6	3.06	9.5	11.0	1	
1405	β 23	7 56.2	+ 3 26	17.23	180.6	2.79	8.3	11.8	3	
1413	β 203	7 57.7	−27 13	16.12	243.7	7.01	7.7	8.7	3	*A* and *B*
				18.18	241.7	6.81	7.6	9.6	5	*A* and *B*
				18.18	71.2	63.56		9.5	5	*A* and *C*
1477	Σ 1196	8 5.3	+18 1	18.36	291.1	0.76	5.2	5.5	3	*A* and *B*
				18.36	112.0	5.08		6.2	3	*A* and *C*
1708	β 207	8 33.3	19 49	16.18	100.1	1.24	6.2	10.7	3	(1)
1711	β 208	8 33.9	22 46	18.27	195.7	1.31	6.0	8.4	3	*A* and *B* (9)
				18.23	201.8	84.98	6.0	10.7	5	*A* and *C*
1723	Σ 1258	8 34.9	+19 18	18.35	331.4	9.88	7.1	7.5	1	
1730	β 209	8 35.4	+39 11	16.11	14	1.25	8.5	8.6	1	
1849	β 24	8 48.4	8 18	16.21	177.3	1.05	7.7	8.8	3	
1853	β 103	8 49.0	7 22	16.96	73.2	2.80	8.1	11.6	1	
1972	Σ 1321	9 6.1	+53 13	18.35	69.1	19.07	6.7	7.0	1	
5030	Σ 1338	9 13.5	+38 12	18.36	179.5	1.31	6.6	7.1	1	(10)
	Espin 718	9 15.1	+52 7	18.08	27.6	7.65	9.3	11.2	5	
5062	β 105	9 17.7	+26 12	16.22	205.6	2.91	5.3	10.8	3	*A* and *B*
				18.27	206.6	3.06	4.8	10.9	1	*A* and *B*
				18.26	211.3	153.07	5.0	10.0	5	*A* and *C*

B. G. C.	* Name	α	δ	1900+	θ	ρ	Mags	Nights	Remarks
		h m	′		°	″			
5071	Σ 1348	9 18.2	+ 6 52	18.31	320.6	1.67	7.5 — 7.7	5	
5094	Σ 1355	9 21.0	+ 6 16	18.32	337.2	2.13	7.5 — 7.7	1	(11)
5181	β 214	9 35.9	−17 56	17.22	256.5	3.03	7.5 — 11.2	3	
5263	β 216	9 51.3	−25 59	18.30	159.1	3.19	6.2 — 14.6	2	
5325	β 217	10 1.3	−21 8	16.18	287.1	1.58	8.2 — 8.3	1	(5)
5329	β 218	10 1.7	−19 7	16.27	129.1	0.86	8.5 — 8.9	3	
5388	γ *Leonis*	10 13.3	+20 27	18.26	117.0	3.96	2.1 — 4.0	5	
.....	*Espin* 432	10 19.0	+33 11	18.09	163.2	3.16	9.5 — 10.1	5	
.....	*Espin* 1151	10 23.6	+11 52	18.11	301.0	2.12	9.6 — 10.3	5	
.....	*Jon* 736	10 24.0	+15 21	18.31	202.2	2.38	10.2 — 10.6	4	
.....	*A* 1350	10 25.3	— 1 49	18.30	324.7	2.15	9.5 — 10.3	5	
5508	Σ 1457	10 32.5	+ 6 21	18.26	324.5	1.32	7.6 — 8.7	5	(12)
5579	β 411	10 45.2	— 8 28	16.21	4.8	3.60	9.7 — 9.8	3	
.....	*Jon* 427	10 57.5	+16 42	17.90	102.4	1.28	9.9 — 10.5	5	
.....	*Espin* 181	11 6.6	+36 22	18.12	142.3	5.51	9.1 — 11.1	5	
5765	Σ 1536	11 17.6	+11 12	18.30	39.2	1.84	4.6 — 7.8	5	(10)
5766	β 26	11 17.7	— 9 16	16.21	68.2	2.53	8.0 — 10.9	3	
.....	*Espin* 1401	11 28.4	+41 31	17.82	328.7	7.00	10.3 — 10.9	2	
6243	γ *Virginis*	12 35.6	— 0 47	18.36	323.1	6.15	3.2 — 3.1	2	
.....	*Jon* 1014	12 47.0	+ 7 48	17.41	61.7	3.78	9.2 — 9.8	2	
6345	β 112	12 54.8	+19 1	16.28	354.1	149.16	6.3 — 9.6	3	*A* and *B*
.....				16.28	292.6	1.82	9.6 — 10.1	3	*B* and *C*
6490	β 237	13 21.0	+15 0	16.29	205.8	2.53	8.3 — 10.8	1	
6528	β 114	13 28.0	— 8 0	16.28	112.6	1.26	7.9 — 8.0	3	
.....	*Espin* 309	13 38.5	+32 10	17.37	135.0	1.95	9.4 — 9.7	1	
6690	β 30	13 52.4	+20 3	16.31	197.7	8.05	8.3 — 11.2	3	
6811	β 116	14 13.0	−13 9	16.31	277.7	3.18	8.4 — 8.5	3	
	Jon 139	14 16.6	+ 1 13	17.37	237.1	4.17	9.4 — 10.5	1	
6857	β 225	14 18.8	−19 26	16.36	295.6	35.30	6.8 — 7.1	1	*A* and *B*
.....				16.36	98.2	1.21	7.5 — 8.5	3	*B* and *C*
6912	β 238	14 27.0	−20 30	16.31	91.0	6.81	8.5 — 11.1	3	
6941	β 226	14 32.4	−21 19	16.38	91.9	1.01	8.2 — 8.6	3	(11)
7041	β 118	14 47.0	−16 1	17.52	301.2	1.70	8.9 — 10.0	1	(1)
7070	β 239	14 51.6	−27 10	17.50	321.5	0.81	6.4 — 6.5	3	
7208	β 228	15 12.6	−23 50	16.53	319.3	0.96	8.3 — 9.0	2	(1)
7336	β 121	15 32.3	−27 15	16.18	277.7	1.13	8.3 — 8.5	3	
7340	β 122	15 33.6	−19 23	16.36	211.2	1.88	7.6 — 7.9	3	
7380	β 240	15 39.5	+ 1 24	16.66	131.5	1.77	8.5 — 10.5	5	*A* and *B*
.....				16.71	38.4	29.23	8.5 — 11.8	4	*A* and *C*
7418	β 36	15 46.1	−21 58	16.18	276.7	2.17	6.4 — 8.7	3	
7476	β 37	15 55.2	−21 15	16.48	41.0	3.03	8.8 — 10.3	3	
7478	β 38	15 55.6	−21 41	16.76	351.4	5.62	8.3 — 10.6	1	
7502	β 39	16 1.0	−12 25	16.51	258.8	3.21	6.5 — 10.9	3	
7530	β 40	16 4.5	−27 11	16.49	356.0	5.37	8.5 — 10.5	3	
7533	β 120	16 5.0	−19 9	16.52	6.5	0.96	4.5 — 6.5	3	*A* and *B*
.....				16.51	336.6	14.42	4.5 — 7.9	1	*AB* and *C*
.....				16.51	50.7	2.14	7.9 — 9.1	1	*C* and *D*
7603	β 41	16 17.1	+61 11	16.65	51.2	1.88	8.7 — 10.6	1	(1)
7712	β 42	16 35.3	+29 15	16.52	41.3	7.62	9.5 — 10.0	5	
7786	β 123	16 47.5	−21 51	16.60	261.3	1.80	8.5 — 9.4	3	

B. G. C.	∗ Name	α	δ	1900 +	θ	ρ	Mags.		Nights	Remarks
		h m				″				
7791	β 241	16 18.4	21 22	16.58	353.2	0.78	7.5	7.5	2	
7887	β 421	17 1.0	− 0 36	17.26	263.5	0.88	7.6	16.1	1	
7951	β 427	17 13.4	−27 43	16.16	93.0	5.10	8.9	10.1	3	
8000	β 428	17 19.4	−26 44	16.56	322.4	3.87	8.0	11.0	3	
8014	β 429	17 21.2	−25 21	17.20	163.6	0.97	7.5	8.2	3	
8288	β 47	17 51.9	10 14	16.92	276.1	1.44	8.6	10.9	3	
8355	β 243	18 0.9	22 47	17.51	121.1	0.61	8.8	9.7	1	*A* and *B*
				16.52	50.8	10.71	8.3	9.3	3	*AB* and *C*
8356	β 244	18 4.0	27 53	17.19	257.6	2.21	8.2	10.2	2	
8371	β 245	18 2.4	−30 15	17.38	354.0	1.65	6.3	9.6	5	
8414	β 134	18 6.7	15 38	16.54	278.4	2.72	7.5	10.5	3	*A* and *B*
8488	β 48	18 13.9	19 13	17.36	360.4	2.07	8.2	16.8	1	
8520	β 49	18 17.0	19 38	16.59	16.9	8.06	8.3	10.9	1	*A* and *B*
8549	β 133	18 20.2	−26 12	16.49	260.7	1.29	7.5	7.8	3	
8617	β 247	18 25.6	− 9 27	16.58	168.3	7.68	8.3	11.2	3	
8710	β 50	18 31.2	+39 29	16.82	329.0	73.81	8.8	10.3	3	*A* and *C*
8804	β 51	18 41.7	+39 34	16.75	186.0	75.03	8.5	10.7	3	*A* and *B*
				16.75	297.2	6.19	10.7	11.5	3	*B* and *C*
9146	β 139	19 7.2	+16 39	17.93	261.1	127.55	7.9	10.1	1	*C* and *D*
9154	β 140	19 10.2	−11 11	16.58	321.4	39.42	7.6	10.5	4	*A* and *B* (1)
				16.61	209.0	7.99	10.6	11.5	3	*B* and *C*
9313	β 142	19 21.5	−12 23	16.55	348.1	1.55	8.1	8.2	1	
9387	β 143	19 26.0	+19 15	16.72	191.8	1.84	8.4	9.8	3	
9424	β 53	19 29.8	+14 11	16.86	250.9	1.52	8.8	10.2	3	
9507	Σ 2557	19 34.8	+29 28	16.74	104.3	11.36	8.2	9.8	2	*A* and *B*
				16.74	304.2	24.73	8.2	11.5	2	*A* and *C*
9594	β 55	19 40.5	+10 16	15.83	26.1	1.29	10.0	10.0	3	*A* and *B*
9623	β 147	19 42.3	+31 48	16.74	300.0	8.80	8.9	10.5	3	
9924	β 58	20 1.8	+15 44	15.77	187.2	9.20	7.2	10.3	3	
10047	β 59	20 10.6	+ 1 45	17.84	144.2	8.39	9.3	10.5	3	
10427	β 267	20 35.1	− 1 19	16.80	239.5	1.75	9.6	9.7	3	
10538	β 66	20 43.0	+27 1	16.84	162.5	1.18	8.3	8.9	3	
10588	β 155	20 47.1	+50 58	17.33	27.0	0.88	7.3	8.0	2	*A* and *B*
10782	β 71	21 1.5	+ 9 39	16.89	275.7	2.12	4.5	10.8	3	*A* and *B*
				16.83	6.1	17.21	4.7	11.5	4	*AB* and *C* (2)
				16.83	152.5	354.03	4.7	6.0	1	*AB* and *D* (4)
10808	β 159	21 6.1	+17 12	16.03	189.4	135.61	6.3	7.2	5	*AB* and *C*
10824	β 160	21 7.8	+15 13	16.75	151.6	57.44	7.7	10.8	3	*A* and *B*
				16.75	141.7	6.01	10.8	11.0	3	*B* and *C*
10884	β 252	21 13.0	−27 19	16.84	272.7	2.10	8.4	8.6	3	(1)
11026	β 73	21 25.2	6 6	15.87	318.8	35.66	3.0	10.1	4	*A* and *B*
				15.90	185.8	57.20		11.3	3	*A* and *C*
11056	β 165	21 27.9	3 59	15.82	178.8	5.31	8.5	10.5	3	
11076	β 166	21 30.3	+59 18	16.80	261.2	0.96			2	
11178	β 274	21 36.4	+38 56	16.76	178.3	3.03	8.3	11.2	3	
11694	β 172	22 17.9	5 27	17.82	311.8	55.58	6.5	11.6	3	*AB* and *C*
				17.82	191.0	115.96	6.5	10.6	3	*AB* and *D*
				17.82	133.3	132.13	6.5	9.8	3	*AB* and *E*
11738	β 173	22 22.4	+56 35	16.83	232.0	2.62	8.3	11.0	3	
11832	β 175	22 29.8	+71 24	16.55	315.8	1.62	10.4	10.3	3	

B. G. C.	✱ Name	α	δ	1900+	θ	ρ	Mags.	Nights	Remarks
		h m	° ′			″			
12012	β 177	22 45.9	−22 21	15.78	97.6	2.62	7.8 — 7.8	3	
12176	β 78	23 2.2	+30 49	15.82	55.2	18.77	7.2 — 10.8	3	*A* and *B*
...				15.82	61.9	48.86	7.2 — 10.9	3	*A* and *C*
12177	β 180	23 2.2	+60 11	15.91	170.5	0.84	7.5 — 8.4	3	*A* and *B* (1)
				15.84	106.2	34.80	7.5 — 10.2	3	*AB* and *C*
12290	β 80	23 12.8	+ 4 45	17.84	359.6	105.72	8.4 — 10.9	3	*AB* and *C* (1)
....				17.84	330.4	192.71	8.4 — 9.4	3	*AB* and *D* (2)
...				17.84	294.8	206.07	8.4 — 9.7	3	*AB* and *E*
12308	β 229	23 14.4	+56 35	15.79	35.9	17.42	7.0 — 11.7	3	
12316	β 278	23 15.3	+61 33	15.88	175.1	12.93	7.0 — 11.6	3	
12655	β 280	23 51.8	+56 43	16.80	71.1	1.13	8.4 — 8.8	3	*A* and *B*
				16.55	191.1	8.37	8.4 — 11.9	3	*A* and *C*

REMARKS

(1) Angle may be decreasing.
(2) Distance apparently increasing.
(3) Both angle and distance seem to be increasing.
(4) Angle fixed, but distance decreasing.
(5) Angle may be increasing.
(6) Binary. Plane of orbit nearly edgewise to us.
(7) This and observations on other wide doubles indicate a systematic tendency of observer to make such distances too large.
(8) In close agreement with my measures in 1916.
(9) Burnham said this "appears to be a most interesting system." The micrometrical measures do not yet explain it. It may be of the 61 *Cygni* class.
(10) This is certainly a binary.
(11) Angle is probably increasing.
(12) Relative motion is probably rectilinear.

University of Minnesota, Minneapolis, Minn. May 7, 1923.

PARALLAXES OF FIFTY-NINE STARS,

DETERMINED BY PHOTOGRAPHY WITH THE 26-INCH MCCORMICK REFRACTOR,

By HAROLD L. ALDEN.

This list of parallaxes is in continuation of those published in the *Astronomical Journal* Nos. 778, 796, 803, and 808. Some changes have been made in the form of presenting the data but the headings of the various columns are self-explanatory. An asterisk following the catalog proper-motion indicates that this quantity has been taken from *Cincinnati Publications* 18. The parallaxes given are relative to the mean parallax of the comparison stars of about the tenth magnitude, the reduction to absolute parallax being $+0''.005$.

The list contains the parallaxes of thirteen stars brighter than magnitude 2.0 and also the parallaxes of faint companions of two of them. Because of the effective elimination of magnitude equation by the means described briefly in *Popular Astronomy* 28, 517, 1920 and the care taken in securing plates under good conditions, these parallaxes probably give, for the majority of the first magnitude stars in the list, the most reliable trigonometrical data that has been published up to the present time.

No.	Star	1900 R. A.	1900 Decl.	Magnitude and Spectrum	Proper-motion Total	Proper-motion Right Ascension Boss	Proper-motion Right Ascension Observed	Relative Parallax	Probable Error	Notes
		h m	° ′		″	″	″	″	″	
443	ξ *Cassiopeia*	0 31.1	+53 21	3.7 B3	0.023	+0.021	+0.014	−0.025	±0.005	
444	16 *Persei*	2 44.2	+37 51	4.3 F0	0.214	+ .186	+ .170	+ .016	.010	*a*
445	τ *Persei*	2 47.2	+52 21	4.1 G0	0.008	+ .005	− .024	+ .015	.007	
446	*Lalande* 5761	3 2.5	+25 59	8.0 F2	0.861	− .201*	− .177	+ .010	.007	
447	δ *Persei*	3 35.8	+47 28	3.1 B5	0.145	+ .032	+ .016	+ .001	.011	*a*

No.	Star	1900 R. A.	1900 Decl.	Magnitude and Spectrum	Proper-motion Total	Proper-motion Right Ascension Boss	Proper-motion Right Ascension Observed	Relative Parallax	Probable Error	Notes
		h m	° ′		″	″	″	″	″	
448	*ε Persei*	3 51.1	+39 43	3.0 B1	0.040	+ .027	− .009	− .013	± .011	
449	*37 Tauri*	3 58.8	+21 49	4.5 K0	0.113	+ .093	+ .074	+ .025	.011	
450	*μ Persei*	4 7.6	+48 9	4.3 G0	0.030	+ .013	− .008	+ .023	.011	
451	*A. G. Berlin* 1366	4 8.6	+22 6	9.1 A8	0.54	+ .145*	+ .124	− .016	.009	
452	*B. D.* 21 608	4 8.9	+22 2	9.1			− .004	− .023	.010	
453	*SZ Tauri*	4 31.4	+18 20	7.1 G0	0.016	…	− .066	+ .010	.009	
454	*η Aurigæ*	4 59.5	+41 6	3.3 B3	0.081	+ .030	+ .029	+ .012	.008	*a*
455	*α Aurigæ*	5 9.3	+45 54	0.2 G0	0.437	+ .084	+ .099	+ .078	.008	
456	*Companion*	5 10.0	+45 44	10.5	0.422	+ .067	+ .062	+ .063	.007	*b*
	Mean							+ **.069**	**.005**	
457	*γ Orionis*	5 19.8	+ 6 16	1.7 B2	0.026	− .007	.000	+ .024	.007	
458	*β Tauri*	5 20.9	+28 31	1.8 B8	0.180	+ .032	+ .025	+ .030	.008	
459	*Lalande* 10299	5 23.5	− 3 34	8.6 K0	0.841	− .292*	− .286	+ .061	.009	
460	*δ Orionis*	5 26.9	− 0 22	2.5 B0	0.004	+ .002	+ .014	+ .006	.010	
461	*α Orionis*	5 49.8	+ 7 23	0.9 Ma	0.029	+ .028	+ .030	+ .013	.006	
462	*RT Aurigæ*	6 22.1	+30 33	5.3 G0	0.024	− .006	− .006	− .002	.008	
463	23 *H Camelop.*	6 29.2	+79 40	5.6 F8	0.620	− .073	− .050	+ .042	.013	
464	*γ Geminorum*	6 31.9	+16 29	1.9 A0	0.065	+ .015	+ .017	+ .028	.006	
465	*λ Geminorum*	7 12.3	+16 43	3.6 A2	0.068	− .018	− .033	+ .031	.010	
466	*β Geminorum*	7 39.2	+28 16	1.2 K0	0.625	− .622	− .591	+ .107	.012	
467	*Lalande* 17161	8 38.6	+42 3	8.2 K0	0.702	− .269	− .269	+ .045	.014	
468	12 *Hydræ*	8 41.7	−13 11	4.4 G5	0.031	+ .025	+ .027	− .005	.010	
469	*Fedorenko* 1384 *Br.*	8 46.0	+71 11	8.7 K6	1.390	−1.343*	−1.292	+ .083	.019	
470	*Fedorenko* 1384 *Ft.*	8 46.0	+71 11	9.1 K9	1.390	…	−1.329	+ .075	.012	
	Mean							+ **.077**	**.010**	
471	*θ Hydræ*	9 9.2	+ 2 44	3.8 A0	0.338	+ .130	+ .164	+ .020	.011	*a*
472	*α Lyncis*	9 15.0	+34 49	3.3 K5	0.216	− .217	− .219	+ .007	.008	*a*
473	*α Leonis*	10 3.0	+12 27	1.3 B8	0.248	− .248	− .231	+ .059	.013	
474	*Companion*	10 2.9	+12 29	7.6 G	0.252	− .252*	− .250	+ .066	.012	
	Mean							+ **.063**	**.009**	
475	*ρ Leonis*	10 27.5	+ 9 49	3.8 B0p	0.010	− .008	+ .020	+ .026	.011	
476	*δ Crateris*	11 14.3	−14 14	3.8 K0	0.230	− .124	− .131	+ .001	.011	
477	*δ Corvi*	12 24.7	−15 58	3.1 A0	0.252	− .208	− .147	− .007	.009	
478	*Lalande* 24774	13 16.1	+43 38	8.2 K0	0.438	− .430*	− .440	+ .024	.008	
479	*α Virginis*	13 19.9	−10 38	1.2 B2	0.054	− .044	− .040	+ .009	.010	
480	*η Ursæ Majoris*	13 43.6	+49 49	1.9 B3	0.119	− .117	− .110	+ .001	.011	
481	*α Bootis*	14 11.1	+19 42	0.2 K0	2.282	−1.101	−1.078	+ .076	.008	
482	*Boss* 4188	16 22.3	− 7 22	5.1 Ma	0.176	+ .036	+ .017	+ .012	.009	
483	*α Scorpii*	16 23.3	−26 13	1.2 Ma	0.034	− .007	− .001	+ .025	.007	
484	*ζ Herculis Br.*	16 37.5	+31 47	3.0 G0	0.604	− .465	− .461	+ .115	.008	
485	Σ 2173	17 25.2	− 0 59	5.3 G5	0.215	− .121	− .121	+ .030	.009	
486	*α Lyræ*	18 33.6	+38 41	0.1 A0	0.346	+ .201	+ .222	+ .131	.006	
487	*ζ¹ Lyræ*	18 41.3	+37 30	4.3 A3	0.031	+ .026	+ .004	+ .012	.007	
488	*ζ² Lyræ*	18 41.3	+37 29	5.9 A3	0.022	+ .019	+ .016	+ .038	.010	
	Mean							+ **.021**	**.006**	

No.	Star	1900 R. A.	1900 Decl.	Magnitude and Spectrum	Proper-motion Total	Proper-motion Right Ascension Boss	Proper-motion Right Ascension Observed	Relative Parallax	Probable Error	Notes
		h m	° ′		″	″	″	″	″	
489	β *Scuti*	18 41.9	− 4 51	1.5 G0	0.025	− .010	− .018	+ .013	± .009	*a*
490	12 *Aquilae*	18 56.3	− 5 53	4.2 K0	0.048	− .031	− .028	+ .029	.006	
491	α *Vulpeculae*	19 24.5	+24 28	4.6 Ma	0.170	− .127	− .103	− .006	.011	
492	β *Sagittae*	19 36.6	+17 15	4.4 G8	0.038	+ .001	+ .027	− .014	.008	
493	δ *Cygni*	19 41.8	+44 53	3.0 A	0.065	+ .053	+ .036	+ .021	.013	
494	W_1 19h 1190	19 49.2	+ 1 41	8.5 K0	0.299	− .013*	+ .021	+ .036	.014	
495	W_1 19h 1196	19 49.4	+ 1 41	8.8 K0	0.29	.000*	+ .031	+ .010	.010	
	Mean							+ **.022**	**.007**	
496	*Groombridge* 3215	20 29.3	+41 33	7.0 K0	0.475	− .161*	− .157	+ .039	.010	
497	α *Cygni*	20 38.0	+44 55	1.3 A2	0.001	.000	− .001	+ .002	.005	
498	*Groombridge* 3263	20 38.2	+60 9	6.0 F5	0.186	+ .003	+ .014	+ .032	.011	
499	β *Cephei*	21 27.4	+70 7	3.3 B1	0.012	+ .011	+ .032	+ .011	.008	
500	δ *Cephei*	22 25.5	+57 54	4.1 G0	0.012	+ .012	+ .009	+ .002	.009	
501	α *Lacertae*	22 27.2	+49 46	3.8 A	0.141	+ .110	+ .127	+ .018	.010	

a. Partly measured by Miss Mott.
b. Proper-motion from *A. N.* 4715.

ander McCormick Observatory, University, Virginia
April 17, 1923.

OBSERVATIONS OF BAADE'S COMET,

MADE WITH THE $10\frac{1}{2}$-INCH EQUATORIAL OF THE UNIVERSITY OF MINNESOTA,

By F. P. LEAVENWORTH.

Date		G. M. T.	Δα	Δδ	Comps.	α App.	δ App.	log pΔ		★
1922		h m s	m s	′ ″		h m s	° ′ ″			
Oct.	21	12 53 43	−0 2.32	−3 5.5	6 6	19 57 51.38	+36 19 52.2	9.074	0.143	1
Nov.	15	13 4 48	+1 19.70	−2 44.7	4 4	20 50 32.50	30 1 46.2	9.301	0.402	2
	16	15 52 15	+0 24.80	+7 44.9	6 6	20 53 19.14	29 43 15.8	9.650	0.619	3
	22	13 49 32	+0 28.27	+1 12.7	6 6	21 8 8.20	28 7 24.8	9.466	0.501	4
	24	16 6 29	+1 8.12	−7 7.3	4 4	21 13 23.78	27 34 31.6	9.651	0.668	5
	27	15 21 29	+0 36.97	−1 8.1	7 8	21 20 51.94	26 48 54.7	9.618	0.629	6
	28	12 17 57	+0 13.23	+1 27.9	5 6	21 23 3.42	26 35 43.3	9.146	0.158	7
Dec.	1	13 30 28	−0 18.21	+6 30.4	6 6	21 30 42.88	25 50 48.2	9.443	0.530	8
	8	13 12 4	−0 8.92	−6 9.8	6 6	21 48 9.84	24 13 36.2	9.415	0.549	9
	8	13 48 46	−0 6.08	−6 31.2	4 4	21 48 12.68	24 13 14.8	9.500	0.580	9
	15	13 12 45	−0 5.61	+8 33.5	8 8	22 5 26.06	22 41 59.1	9.437	0.584	10
	19	13 15 49	−0 6.59	−0 14.7	4 4	22 15 11.82	21 58 39.4	9.458	0.596	11
	24	13 20 16	−0 3.60	−3 6.4	6 6	22 20 2.43	21 36 27.8	9.472	0.606	12
1923	29	13 20 42	+0 10.47	−0 2.3	6 6	22 39 6.07	20 16 27.4	9.495	0.634	13
Jan.	14	13 19 55	+0 17.47	−1 18.5	5 6	23 15 43.54	18 12 13.1	9.533	0.668	14
	14	13 39 47	−0 21.60	+4 34.9	4 4	23 15 45.17	18 12 15.3	9.560	0.689	15
	21	12 51 1	+0 1.37	+2 20.5	8 8	23 31 2.66	17 31 51.2	9.501	0.665	16

Date		G. M. T.	Δα	Δδ	Comps.	α App.	δ App.	log pΔ		★
1923		h m s	m s	′ ″		h m s	° ′ ″			
Jan.	21	13 30 58	+0 15.15	−1 19.9	3 3	23 37 33.60	17 16 10.5	9.570	0.694	17
	21	13 30 58	+0 5.46		2	23 37 33.26		9.570		18
Feb.	1	13 17 3	−0 11.25	+1 13.0	5 6	0 0 36.60	16 31 17.6	9.582	0.713	19
	1	13 21 29	+0 14.34	−1 14.4	5 6	0 0 37.11	16 31 51.7	9.575	0.710	20
	9	13 59 12	+0 12.89	+2 1.2	4 4	0 10 50.07	16 16 17.4	9.617	0.739	21
	16	13 48 4	+0 8.72	+0 3.2	6 6	0 21 45.50	+15 58 30.0	9.618	0.740	22

Mean Places of Comparison Stars for 1922.0 and 1923.0

★	α	δ	Red. to App. α	Red. to App. δ	Authority
	h m s	° ′ ″	s	″	
1	19 57 51.86	+36 22 25.4	+1.84	+32.6	*A. G. Lund* 8930
2	20 49 10.85	30 3 58.9	+1.95	+32.0	*A. G. Camb. Eng.* 11863
3	20 52 52.36	29 34 59.0	+1.98	+31.9	*A. G. Camb. Eng.* 11922
4	21 7 37.89	28 5 40.4	+2.04	+31.7	*A. G. Camb. Eng.* 12224
5	21 12 13.60	27 44 7.4	+2.06	+31.5	*A. G. Camb. Eng.* 12296
6	21 20 12.88	26 49 31.6	+2.09	+31.2	*A. G. Camb. Eng.* 12447
7	21 22 48.10	26 33 44.3	+2.09	+31.1	*A. G. Camb. Eng.* 12492
8	21 30 58.97	25 43 47.4	+2.12	+30.7	*A. G. Camb. Eng.* 12656
9	21 48 16.56	24 19 45.9	+2.20	+30.1	*Paris Ph.* +24° 21ʰ 44ᵐ No. 274
10	22 5 29.43	22 35 56.6	+2.24	+29.0	*A. G. Berlin B* 8538
11	22 15 16.11	21 58 25.5	+2.30	+28.6	*Paris Ph.* +22° 22ʰ 16ᵐ No. 495
12	22 20 3.71	21 39 6.0	+2.32	+28.2	*Paris Ph.* +22° 22ʰ 16ᵐ No. 699
13	22 38 53.21	20 16 3.0	+2.36	+26.7	*A. G. Berlin A* 9286
14	23 14 56.59	18 13 27.2	−0.52	+ 4.4	*A. G. Berlin A* 9527
15	23 16 10.28	18 7 36.0	−0.51	+ 4.4	*Bord. Ph.* +17° 23ʰ 16ᵐ No. 33
16	23 31 1.80	17 29 27.9	−0.51	+ 2.8	*Bord. Ph.* +17 23 32 No. 30
17	23 37 18.97	17 18 28.2	−0.52	+ 2.2	*Bord. Ph.* +17 23 32 No. 107
18	23 37 28.32	. .	−0.52		*Bord. Ph.* +17 23 32 No. 110
19	0 0 48.36	16 30 4.5	−0.51	+ 0.1	*Bord. Ph.* +16 0 0 No. 38
20	0 0 23.28	16 33 6.0	−0.51	+ 0.1	*Bord. Ph.* +16 0 0 No. 33
21	0 10 37.70	16 14 17.1	−0.52	− 0.9	*Bord. Ph.* +16 0 8 No. 49
22	0 21 37.29	15 58 28.8	−0.51	− 2.0	*Bord. Ph.* +16 0 24 No. 166

NOTES: The second measure of Dec. 8 was made by E. C. JOHNSON. Nov. 21: Definition bad. Dec. 15: very faint, thru haze. Dec. 19: clouds stopped the observation. Dec. 29: very faint in moonlight. Jan. 18: very faint and difficult. Feb. 9: very faint in haze. Feb. 16: very faint.

Minneapolis, May 19, 1923.

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TRIGONOMETRIC PARALLAX OF THE *PLEIADES*,

DETERMINED BY PHOTOGRAPHY WITH THE 26-INCH McCORMICK REFRACTOR.

By HAROLD L. ALDEN

The *Pleiades* have undoubtedly received more attention from astronomers than any similar group of stars in the sky. This open cluster of fairly bright stars has served as the proving ground for numerous new developments in research methods, particularly in photographic astronomy. The magnitudes of the stars, visual, photovisual and photographic, have been repeatedly measured. The spectra and motions of the brighter stars are well known. The work of VAN MAANEN[1] and TRUMPLER[2] in recent years has extended our knowledge of the motions to fainter stars and enabled us to differentiate between those which actually belong to the cluster and those which are only optically part of the group.

The distance of the cluster has been derived from various theoretical considerations, but at the time the present investigation was begun there had been published but one directly determined parallax for any of the stars known to share the motion of the group. SMITH with the Yale Heliometer measured the parallax of an eighth magnitude star, obtaining the value $-0''.032 \pm 0''.014$. Thus it seemed worth while to make a direct determination of the parallax of the cluster by means of photography with a telescope of long focus.

The following results are based on the measurement of forty-eight plates taken with the 26-inch McCormick refractor. These plates are divided into three series. The first series was centered near *Alcyone* and contains twenty plates distributed over six seasons. The other two series were centered near *Atlas* and *Electra* respectively, and each contained fourteen plates taken in five seasons.

The rotating sector was used to reduce the light of the brighter stars and in addition a small neutral-tinted gelatin screen absorbing two stellar magnitudes was placed between the photographic plate and the visual-luminosity filter in the plate holder to give added local diminution of brightness. A similar screen of greater density has been successfully used here in connection with the rotating sector for photographing the first magnitude stars. As far as can be detected there is no distortion of the image introduced by the use of such a screen.

The plates were measured on the Gaertner screw machine now used for most of the parallax investigations of this Observatory. Care was taken to place the plates in the machine so that the measures on a given star were made in the same part of the screw for all plates, thus eliminating the effect of progressive errors of the screw. The plates were measured in both the direct and reversed positions in the machine.

Dr. TRUMPLER very kindly furnished, in advance of publication, information regarding the motions of the stars to be found on the plates. This data permitted the selection of a representative list of cluster stars to be measured for parallax and non-cluster stars of small proper-motion for comparison stars. Eight comparison stars were used in each of the first two series of plates and nine in the third. The mean visual magnitudes of the comparison stars for the three series were respectively 10.16, 10.41 and 10.11. These magnitudes, as well as those in Table I, are taken from GRAFF's *Photometrische Durchmusterung der Plejaden*,[3] reduced to the Harvard system by subtracting 0.30 magnitude.

The stars measured for parallax numbered twenty-five, of which seven were on the first set of plates, eight on the second and ten on the third. Of this number, two stars, originally thought to be members of the cluster, were later rejected by TRUMPLER since their motions were found to differ by more than 2''.5 per century from the mean motion of the group. These stars are included in Table I but are omitted from all later discussion. They are Nos. 516 and 520. One star was measured on two overlapping series of plates. Both values are given in the table as well as the weighted mean.

TABLE I RELATIVE PARALLAXES

No.	Star	1900 R. A.	1900 Decl.	Magnitude and Spectrum	Relative Parallax and Probable Error		Series	Number of Plates
		h m	° ′		″	″		
502	[illegible]	3 41.5	+23 48	3.0 B5p	+0.003	±0.011	I	20
503	[illegible]	43.2	+23 45	3.8 B8	−0.030	.013	II	13
504	[illegible]	38.9	+23 48	3.9 B5p	+0.016	.009	III	14
505	*Pleione*	43.2	+23 50	5.1 B8p	−0.016	.009	II	14
506	*Celaeno*	38.9	+23 58	5.5 B5	+0.008	.006	III	14
507	217	41.5	+23 36	7.3 B9	−0.003	.012	I	20
508	209	41.4	+23 50	8.2 A0	+0.040	.014	I	20
509	202	41.3	+23 19	8.7 G0	+0.027	.008	I	20
510	307	42.6	+23 52	9.1 F8	+0.011	.008	I	20
					+0.027	.009	II	14
					+0.018	.006	Mean	
511	275	42.2	+23 50	9.2 G0	+0.042	.007	II	14
512	169	40.7	+23 18	9.4 F8	0.000	.012	III	14
513	196	41.2	+23 58	9.4 F8	+0.029	.009	I	20
514	109	39.7	+23 59	9.4	+0.004	.008	III	13
515	296	42.5	+23 18	9.9	−0.003	.010	II	14
516	32	38.2	+23 56	10.1	−0.012	.009	III	14
517	69	39.0	+24 7	10.2	−0.003	.008	III	14
518	286	42.3	+23 35	10.2	+0.005	.010	II	14
519	216	41.5	+23 36	10.4	+0.013	.009	I	19
520	11	38.3	+23 57	10.5	−0.049	.011	III	14
521	328	42.9	+23 58	10.8	+0.010	.019	II	14
522	110	39.7	+24 7	11.1	+0.005	.010	III	14
523	15	37.9	+23 56	11.1	−0.012	.015	III	14
524	28	38.1	+23 58	11.3	−0.014	.014	III	14
525	392	43.6	+23 59	11.4	−0.035	.008	II	13

Table I contains the results for the individual stars arranged in the order of brightness. The numbers given in the first column are in continuation of the general number of the published parallaxes of the McCormick Observatory. The second column contains the names of the naked eye stars and the Wolf numbers of those fainter than the sixth magnitude. The spectra are taken from the *Draper Catalog.* The last two columns give the series number and the number of plates used in the least square solution of the parallax equations.

Omitting Nos. 516 and 520 for the reason given [illegible], we have twenty-three parallaxes of twenty-two stars of the cluster ranging in brightness from magnitude 3.0 to 11.4. Assuming that all of these stars are actual members of the cluster and that there is no measurable dispersion in the parallaxes of the individual members of the group, we have twenty-three determinations of the parallax of the cluster itself. Of these, fourteen are positive, one zero, and eight negative. The range is disappointingly large, from +0″.042 to −0″.035, but values of this size are to be expected if the parallaxes are distributed with respect to the mean according to the law of errors. Assuming that the parallaxes are all of equal weight, the arithmetical mean is +0″.0054 ±0″.0028. The probable error of a single parallax determination is found to be ±0″.0134. Table II gives a comparison between the observed residuals from the mean and those expected

TABLE II

DISTRIBUTION OF RESIDUALS

Limits of residuals	Number of residuals: Expected from theory	Number of residuals: Observed
±0.0000 to ±0.0067	6.1	8
± .0067 to ± .0134	5.4	5
± .0134 to ± .0201	4.3	2
± .0201 to ± .0268	3.1	4
± .0268 to ± .0402	3.1	3
>0.0402	1.0	1

from a strictly Gaussian distribution. The agreement is as good as could be expected from such a limited number of observations. Ten residuals are positive, two zero and eleven negative.

But the parallaxes measured are not all of the same degree of accuracy; therefore, three additional methods of weighting have been employed to derive the most probable parallax of the cluster. The weighted mean parallax, where the weights have been assigned on the basis of the computed probable errors of the individual parallaxes, is $+0''.0078 \pm 0''.0028$. The probable error of the mean is computed from the residuals and the assigned weights, and not from the probable errors of the separate parallaxes.

Since the parallaxes derived from a given series of plates are not altogether independent, the weighted means were derived for each series separately on the basis of probable error. Equal weight was then given to each series. Thus the seven stars in the first series measured on twenty plates were given equal weight with the eight stars in each of the other series which depend on a smaller number of plates. The means are:

Series	Weighted mean parallax
I	$+0''.0179$
II	$+0\ .0031$
III	$+0\ .0039$
Mean	$+0''.0083 \pm 0''.0038$

As is well known, guiding error is dependent upon the difference in brightness between the parallax and comparison stars. Considering the wide range in magnitude of the stars measured, it seemed wise to assign weights based on this difference in brightness. The magnitudes of the parallax stars on the plate as reduced by the rotating sector or screen, if any, were used for this purpose. The weights assigned were as follows:

Difference in magnitude	Weight
0.00 to 1.00	1.0
1.00 2.00	0.7
>2.0	0.5

The weighted mean derived with this system of weights gives for the parallax of the cluster $+0''.0035 \pm 0''.0027$, the probable error of a parallax of unit weight being $\pm 0''.0120$.

This method in effect gives more weight to the fainter stars measured, since the number of bright stars reduced by the rotating sector is small. The smaller value of the mean parallax obtained in this way suggests a possible dependence of parallax on magnitude. In order to test this, the weighted mean parallax was formed for all stars brighter than magnitude 9.0 and for those fainter. Eight stars which have a mean visual magnitude of 5.7 give a weighted mean parallax of $+0''.0084$, while fourteen stars of mean magnitude 10.2 give the value $+0''.0077$. Thus there is no well defined change in parallax with magnitude.

The mean parallaxes obtained by the four methods of combining the data are collected in Table III.

TABLE III

Basis of weights	Mean relative parallax	Probable error
Equal	$+0''.0054$	$\pm 0''.0028$
Probable errors	$+0\ .0078$	$\pm 0\ .0028$
Series equal	$+0\ .0085$	$\pm 0\ .0038$
Difference in brightness	$+0\ .0035$	$\pm 0\ .0027$
Unweighted Mean	$+0''.0062$	

The probable error of the mean is of approximately the same size as that attaching to any one of the above values, namely about $\pm 0''.003$.

This parallax is relative to the mean parallax of the comparison stars of magnitude 10.45. To reduce to absolute parallax, the mean parallax of the comparison stars must be added to the relative value obtained above. STRÖMBERG[4] has shown that the most probable correction to the McCormick relative parallaxes to reduce them to the system on which the spectroscopic parallaxes of ADAMS and his associates are based is $+0''.0053$. This value, however, is for comparison stars on the average three quarters of a magnitude brighter than those employed in the present investigation. Assuming that the difference in brightness is due solely to difference in distance, the correction to absolute parallax for the comparison stars here used is $+0''.0037$. According to VAN RHIJN[5] this parallax corresponds to that of stars of mean magnitude 10.5 having a mean annual proper-motion of $0''.025$. Applying this correction to the mean relative parallax of the cluster we obtain:

ABSOLUTE PARALLAX OF THE *Pleiades* $+$**0''.010**

The probable error of this result is of the order of thirty per cent of its value.

A comparison with other values is interesting.

Mention has already been made of the Yale result. While this investigation was in progress, PITMAN[6] reported at the twenty-sixth meeting of the American Astronomical Society on the parallaxes of four stars in the *Pleiades* determined by photography at the Sproul Observatory. He found for the cluster a relative parallax of $+0''.017 \pm 0''.002$. Two of his stars are contained in this list. They are Nos. 509 and 512. For these stars PITMAN finds a mean parallax of $+0''.014$, the mean of the McCormick parallaxes being $+0''.018$. The agreement is very satisfactory.

Theoretical parallaxes of the *Pleiades* vary somewhat according to the hypotheses on which they are based. In his '*Research on Moving Clusters*', RASMUSON[7] has given a very complete discussion of all results available at that time. The mean parallax based on proper motion and parallactic motion data as found by HARTMANN, HAYN, KAPTEYN, HERTZSPRUNG and others is $+0''.014$. From the luminosity law, VAN SCHOUTEN finds a larger value, namely $+0''.036$. From the relation between spectral type and absolute magnitude, PICKERING, HERTZSPRUNG, DOIG,[8] TRUMPLER and others find the mean parallax $+0''.006$. The hypothetical parallax derived by TRUMPLER from the observed orbital motion of double stars belonging to the cluster is $+0''.010$.

Combining the Sproul and McCormick values, the most probable parallax of the *Pleiades* from direct photographic determinations is $+0''.012$. A correction of $+0''.005$ was applied to the Sproul results for reduction to absolute parallax. This parallax corresponds to a distance of 270 light-years. The diameter of the cluster is then of the order of thirty light-years and the star density is somewhat greater than that found by TRUMPLER. *Alcyone* has an absolute magnitude of -1.6. The mean absolute magnitude of six stars of spectral type B5 is -0.4 and of sixteen stars of types B8 and B9 is $+1.6$.

A solution was made for the apex of motion of the *Pleiades* using this value for the parallax. The radial velocity was taken as 9 kilometers per second after correcting for the K term. The mean proper motion of all the *Pleiades* stars contained in Boss' *Preliminary General Catalog* provides the best data on which to base such a determination. KAPTEYN[9] has suggested the probability of a systematic correction to the proper motions in declination of the *P. G. C.*, and derived a value for that correction of $+0''.0130 \cos D$. The writer has made a preliminary determination of this correction[10] and finds for the coefficient $+0''.0075 \pm 0''.0025$. Recently VAN RHIJN and VAN DE KAMP[11] have published the value $+0''.0061 \pm 0''.0013$. The mean of these three determinations is $+0''.009 \cos D$. The mean proper motion of twelve *Pleiades* stars in right ascension is $+0''.023$ and the corrected motion in declination $-0''.043$. With this data the *Pleiades* are found to be moving with a velocity of 21.2 kilometers per second toward the point whose right ascension is $86^\circ.5$ and declination $-33^\circ.9$. This is only six degrees from the solar antapex computed from stars of later type[12] and still nearer to the position frequently adopted at right ascension 90° and declination -30°. The velocity is practically that found for the Sun's motion in space. If the Sun's motion is eliminated, the *Pleiades* are nearly stationary with respect to the centroid of stars on which the solar motion is based.

SUMMARY

Parallaxes have been derived from photographs taken with the McCormick refractor for twenty-two stars which are members of the *Pleiades* cluster, one star having been observed on two series of plates.

The most probable relative parallax of the cluster from this data is found to be $+0''.0062$ with a probable error of the order of $\pm 0''.003$.

The absolute parallax of the *Pleiades*, after allowing for the parallax of the comparison stars, is $+0''.010$. Combined with the parallaxes of four stars determined photographically at the Sproul Observatory, the absolute parallax is $+0''.012$.

The motion of the *Pleiades* is computed to be very nearly in the direction of the solar antapex with a velocity closely approximating the Sun's velocity. The cluster is therefore relatively fixed in space.

Leander McCormick Observatory, University, Virginia,
May 14, 1923.

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[1] *Contributions from the Mount Wilson Observatory* No. 167.

[2] *Lick Observatory Bulletin* No. 333.

[3] *Astronomische Abhandlungen der Hamburger Sternwarte in Bergedorf.* Band II, Nr. 3.

[4] *Contributions from the Mount Wilson Observatory* No. 220.

[5] *Publications of the Kapteyn Astronomical Laboratory at Groningen.* No. 34. Page T10.

[6] *Popular Astronomy* 29, 639, 1921. See also *Astronomical Journal* 34, 119.

[7] *Meddelanden fran Lunds Astronomiska Observatorium*, Serie II, Nr. 26.

[8] *Monthly Notices* 82, 461, 1922.

[9] *Bulletin of the Astronomical Institutes of the Netherlands*, No. 11.

[10] *Popular Astronomy*, 31, 185, 1923.

[11] *Bulletin of the Astronomical Institutes of the Netherlands*, No. 36.

[12] *Contributions from the Mount Wilson Observatory* No. 141.

OCCULTATION OF *ALDEBARAN*,

By S. A. MITCHELL and HAROLD L. ALDEN

The occultation of *Aldebaran* by the *Moon* was observed at the McCormick Observatory in full daylight on the 19th of April under excellent conditions of seeing and transparency. MITCHELL observed with the 26-inch refractor and ALDEN with the 5-inch finder attached to the larger instrument. The chronometer used was rated by means of wireless signals from Arlington at noon on April 19 and 21. The observed times are as follows:

Observer		Greenwich Mean Time Immersion	Emersion
MITCHELL	1923 April 19^d	$10^h\ 20^m\ 1.7$	$11^h\ 36^m\ 52.7$
ALDEN		20 1.7	36 52.2

Leander McCormick Observatory, University, Virginia,
May 14, 1923.

OBSERVATIONS DE LA *LUNE* ET PLANÈTES,

FAITES A LA LUNETTE MÉRIDIENNE DE L'OBSERVATOIRE DE BESANÇON,

PAR M. LOUIS PERROT

Lune

Dates			Tm Besançon	Bord.	AR Apparente	Cor d'ephem C. d. T	Bord	DP Apparente	Cor d'ephem C. d. T
			h m s		h m s	s		° ′ ″	″
1921	Fevrier	15	5 55 28.48	1er	3 36 10.64	+1.24	I	72 59 57.3	− 1.1
		16	6 51 10.93		4 35 58.79	+1.32	I	71 19 29.8	− 3.1
		17	7 49 24.41		5 38 18.38	+1.39	I	70 51 0.8	− 0.6
		18	8 49 7.72		6 42 8.06	+1.60	I	71 43 12.7	+ 1.8
		19	9 49 0.76		7 46 7.49	+1.23	I	73 56 26.4	+ 1.8
		21	11 44 54.42		9 50 13.30	+1.18	I	81 39 31.1	+ 3.0
		22	12 39 55.85	2e	10 49 20.32	+1.21	I	86 28 32.9	+ 1.2
		23	13 33 7.51		11 46 37.27	+0.96	I	91 24 50.8	+ 1.4
		24	14 24 54.48		12 12 29.29	+0.91	I	96 7 33.8	+ 6.4
	Mars	19	8 34 42.97	1er	8 22 0.96	+1.32	S	75 52 20.2	+ 0.6
		21	10 25 3.19		10 20 32.71	+1.29	S	81 6 41.8	+ 1.2
		22	11 18 12.47		11 17 16.97	−0.27	S	88 51 53.6	+ 6.0
		23	12 10 26.61		12 11 6.24	+0.64			
	Juin	17	10 0 54.08	1er	15 43 16.10	+0.86	S	106 58 15.4	+ 3.3
	Juillet	16	9 37 24.27	1er	17 14 2.58	+0.91	S	108 50 31.3	− 1.0
		19	12 1 11.61		19 50 3.21	+0.78	S	105 58 21.5	− 0.5
1921	Novembre	11	12 9 29.96	2e	3 47 32.76	+0.79	I	73 29 53.0	−12.5
1922	Fevrier	9	10 7 2.	1er			S	73 2 10.8	−11.3
		11	12 5 41.91		9 30 11.03	+0.15	I	79 17 51.9	−17.1
	Mai	8	9 55 41.16		12 59 22.45	+0.09	S	95 35 31.0	−23.5
		9	10 49 57.94		13 57 14.70	−0.02	S	99 53 57.5	−20.1
	Juillet	7	11 2 53.25		18 3 18.96	+0.23	S	108 25 11.6	− 5.5

T		T_0 Besançon	AR Apparente	Corr. d'éphém. C. d. T.	DP Apparente	Corr. d'éphém. C. d. T.	Diamètre Horizontal	Diamètre Vertical
				Mars				
1922		h m s	h m s	s	° ′ ″	″	s	″
Juin	19	11 7 29.10	16 56 57.51	0.20	116 6 14.0	+6.0	1.79	25.6
	20	11 2 10.61	55 31.73	0.09	6 12.3	+1.6	1.78	25.2
Juillet	3	9 56 33.35	11 1.93	−0.47	7 20.0	+5.4	1.73	14.3
	7	9 37 35.85	37 17.54	−0.47	6 31.3	+1.3	1.65	19.4
	20	8 41 16.37	16 36 1.62	−0.26	116 7 34.4	+1.5	1.54	17.5
				Jupiter				
1921								
Février	23	12 54 9.65	11 7 33.01	+0.06	82 19 41.4	−0.8	3.02	44.5
	24	49 45.78	7 4.96	+0.08	46 39.0	+0.2	3.05	44.7
	25	45 21.63	6 36.65	+0.01	13 34.7	−0.5	3.10	44.9
	28	12 32 8.48	11 5 10.99	+0.09	34 21.8	+0.4	3.07	43.9
Mars	17	11 17 12.26	10 57 3.84	+0.06	81 43 26.5	−0.2	3.09	43.1
	19	11 8 26.10	56 9.34	+0.06	37 52.7	−2.1	3.10	44.4
	21	10 59 11.16	55 16.07	+0.15	32 30.5	−1.3	3.05	43.6
	22	55 19.03	54 19.77	+0.06	29 53.6	−0.4	3.05	43.8
	23	50 57.53	54 24.01	+0.19	27 19.2	+0.5	3.00	. . .
	24	46 36.03	53 58.14	+0.12	24 45.7	−0.3	3.13	44.2
	31	10 16 17.70	10 51 11.00	+0.13	81 8 18.2	−0.3	3.01	42.1
Avril	2	10 7 42.19	10 50 27.18	+0.09	81 4 4.7	−0.1	3.01	43.2
	5	9 54 52.90	49 25.14	+0.23	80 58 10.0	−0.3	3.18	42.1
	9	9 37 54.18	48 10.45	+0.14	51 10.4	+1.1	2.95	42.4
	11	9 29 28.87	47 36.55	+0.15	48 1.4	0.0	2.92	41.9
	16	9 8 35.37	10 46 22.38	+0.08	80 41 21.8	−0.1	2.94	43.2
1922								
Avril	14	11 19 54.93	12 49 9.76	+0.12	93 32 49.6	0.5	3.15	47.5
	27	10 23 14.14	43 34.85	0.07	92 59 2.9	+0.2	2.93	43.0
Mai	6	9 44 35.32	40 24.68	+0.09	40 10.8	0.7	2.96	43.3
	8	9 36 6.42	39 44.20	+0.08	36 . .		2.93	41.6
	19	8 50 5.97	12 36 58.59	+0.05	92 21 35.2	−0.9	2.76	42.1
				Saturne				
1921								
Février	23	13 23 27.09	11 36 55.26	−0.07	84 57 5.8	−2.1	1.45	19.2
	24	19 15.21	36 39.24	−0.09	55 14.7	−0.9	1.43	19.0
	25	15 3.16	36 23.06	−0.10	53 21.4	−1.5	1.46	19.1
	28	13 2 26.27	11 35 33.76	−0.06	84 47 39.1	−1.2	1.42	18.8
Mars	17	11 50 13.93	11 30 11.01	0.02	.	.	1.50	. .
	19	12 17.65	30 6.45	0.05	84 14 11.4	−2.0	1.47	20.3
	21	33 54.67	29 32.19	−0.02	7 29.4	2.3	1.40	19.4
	22	29 38.72	29 15.40	0.09	5 40.3	−2.0	1.38	19.0
	23	25 26.00	28 58.24	0.01	3 51.9	1.9	1.50	21.1
	24	11 21 13.30	28 41.40	0.01	84 2 1.2	−2.4	1.55	20.9
	31	10 54 47.89	11 26 17.02	+0.01	83 50 4.9	−1.4	1.48	19.7
Avril	2	10 43 21.80	11 26 15.66	−0.04	83 46 51.0	−1.1	1.41	19.7
	5	30 54.64	25 30.09	−0.03	42 11.3	−1.2	1.37	19.9

Dates		Tm Besancon	AR Apparente	Corr. d'ephem. C. d. T.	DP Apparente	Corr d'ephem. C. d. T.	Diamètre Horizontal	Diamètre Vertical
				Saturn (Continued)				
1921		h m s	h m s	s	° ′ ″	″	″	″
	9	10 14 10.36	11 24 32.28	−0.01	83 36 21.3	−1.8	1.39	20.8
Avril	11	10 5 51.20	21 1.86	+0.08	33 38.0	−1.1	1.30	18.1
	16	9 45 7.47	23 0.48	−0.10	27 21.6	−1.6	1.41	18.9
	27	8 59 57.12	11 21 5.10	−0.01	83 16 10.1	−1.3	1.31	19.3
1922								
Avril	14	10 11 59.54	12 11 11.15	−0.07	88 40 37.0	−1.2	1.41	19.8
	27	9 50 18.89	11 7.29	−0.10	22 13.4	−1.2	1.26	18.2
Mai	6	9 12 43.60	9 24.89	−0.15	12 ..		1.11	20.2
	8	9 5 32.41	12 9 5.50	−0.07	88 10 51.8	−0.6	1.31	20.2
1922				*Uranus*				
Octobre	13	9 21 39.97	22 18 11.28	+0.07	98 28 56.0	+0.1	.	. .
	14	9 17 37.69	18 4.89	−0.11	29 33.5	+1.7		.
	17	9 5 32.31	22 47 47.18	+0.01	98 31 15.0	+0.5		

Neptune

Dates		Tm Besancon	AR Apparente	Cor. d'ephem. C. d. T.	DP Apparente	Cor. d'ephem. C. d. T.
1921		h m s	h m s	s	° ′ ″	″
Fevrier	19	11 0 6.60	8 57 25.01	−0.08	72 13 3.2	−1.0
	21	10 52 2.27	57 12.46	−0.09	42 11.2	+0.1
	22	48 0.12	57 6.20	−0.16	41 14.2	−0.2
	23	43 58.11	57 0.08	−0.14	41 17.9	−0.4
	24	39 56.17	8 56 51.02	0.11	40 51.8	0.7
	25	35 54.27	56 48.02	0.08	40 27.0	+0.1
	26	31 52.39	56 42.03	0.11	40 1.1	−0.5
	28	10 23 48.81	8 56 30.27	−0.15	72 39 10.7	−1.1
Mars	1	10 19 47.22	8 56 24.54	−0.11	72 38 47.1	−0.2
	2	15 45.67	56 18.87	−0.09	38 23.1	−0.1
	3	10 11 44.23	56 13.32	−0.02	37 58.6	−0.8
	8	9 51 37.75	55 46.30	0.13	36 5.3	0.0
	9	47 36.76	55 41.20	0.09	35 42.7	−0.9
	10	43 35.80	55 36.14	0.11	35 22.1	0.0
	12	35 34.20	55 26.32	0.12	34 39.9	−0.6
	14	27 33.02	55 16.92	−0.08	34 0.3	−0.3
	15	9 23 32.48	55 12.29	0.15	33 40.7	0.5
	22	8 55 32.21	54 43.31	0.02	31 37.8	+0.1
	23	8 51 32.58	54 39.54	0.06	31 21.2	0.7
	24	8 47 33.01	8 54 35.86	−0.13	72 31 .6.0	−0.1
1922						
Fevrier	9	11 50 10.01	9 7 43.59	0.24	73 22 11.9	−1.7
	11	11 42 35.01	7 30.33	0.17	21 42.0	2.2
	24	10 50 4.93	6 .6.83	−0.08	15 31.2	−1.0
Mars	16	9 29 37.64	9 4 17.37	−0.26	7 28.5	−0.6
	17	9 25 36.6	. . . .	. . .	7 8.3	−0.6
	18	9 21 36.87	9 4 8.38	−0.17	73 6 48.2	−0.9

Date	Tm Besançon	AR Apparente	DP Apparente
		Ceres 1	
1921	h m s	h m s	° ′ ″
Fev. 18	7 19 19.15	5 12 9.97	60 10 21.1
19	15 39.63	12 26.10	38 14.1
21	38 25.29	13 3.68	36 0.3
23	31 18.18	13 18.50	31 55.2
Mars 1	7 10 37.10	5 16 13.61	60 29 10.8
1922			
Mai 6	11 10 29.22	14 6 29.69	90 11 18.0
8	11 1 58.61	5 50.80	11 39.6
19	10 *11 11.10	13 58 50.13	28 5.5
20	10 5 14.59	56 13.11	30 15.9
22	9 57 8.85	56 2.16	35 5.8
23	52 39.36	55 28.48	37 15.0
24	18 14.30	54 56.21	40 33.6
27	31 51.81	53 27.21	49 53.5
29	9 26 16.77	13 52 34.88	90 55 55.6
		Pallas 2	
1922			
Mai 6	9 33 15.08	12 28 59.58	68 59 5.0
8	9 25 33.95	12 29 10.30	68 18 47.3
		Junon 3	
1921			
Juill. 6	11 20 28.29	18 17 57.36	95 3 13.8
8	10 53.19	16 11.11	8 31.3
9	6 6.61	15 23.59	11 5.1
22	10 14 56.60	5 20.11	55 17.8
25	9 50 15.38	18 2 21.80	96 7 56.7
1922			
Nov. 16	11 31 55.79	3 15 51.81	94 31 9.3
21	11 16.71	12 21.71	94 58 30.4
Dec. 8	9 56 5.10	3 29.12	95 48 36.2
11	11 26.79	3 3 38.57	95 44 0.0
		Vesta 4	
1921			
Nov. 15	11 26 54.78	3 4 50.58	82 30 38.1
17	17 2.28	2 19.57	34 20.8
18	12 6.67	1 49.74	36 0.3
19	7 11.76	3 6 50.54	37 23.2
22	10 52 30.71	2 57 56.75	41 24.0
23	47 38.59	57 0.39	42 25.1
24	42 48.84	56 6.10	43 46.7
25	37 23.67	51 36.90	44 1.3
30	14 1.95	50 51.42	45 33.7
Dec. 5	9 50 38.34	17 9.15	13 17.6
6	9 46 1.77	2 16 28.68	82 12 25.8

Dates	Tm Besançon	AR Apparente	DP Apparente
		Flora 8	
	h m s	h m s	° ′ ″
Nov. 13	10 54 44.57	2 23 44.21	87 45 7.3
16	10 39 55.40	2 20 42.38	87 43 17.4
		Metis 9	
1921			
Fev. 19	10 50 10.10	8 47 26.88	62 47 16.4
23	31 21.72	44 24.62	44 8.1
24	26 47.51	43 43.20	40 6.9
25	21 12.38	42 3.72	39 18.9
28	8 37.71	41 16.64	38 5.6
Mars 1	4 10.14	40 44.86	38 14.2
2	9 59 44.48	40 15.05	38 14.8
3	55 20.74	39 47.14	38 36.4
8	33 52.59	37 58.22	43 6.7
9	29 41.23	37 42.73	44 32.9
10	25 31.90	37 29.27	46 8.7
12	17 19.59	37 8.72	49 48.6
14	9 9.27	36 50.15	54 6.5
15	5 16.65	36 53.45	62 56 27.7
21	8 42 25.38	37 37.74	63 4 55.0
23	34 37.93	37 42.11	20 18.4
24	8 30 56.67	8 37 56.79	63 23 50.7
		Victoria 12	
1921			
Juin 23	11 41 46.34	17 48 4.25	103 11 54.2
24	36 56.45	47 10.15	5 16.5
25	32 6.76	46 16.23	102 58 47.8
Juill. 5	10 41 34.28	38 4.51	3 37.6
6	10 40 55.21	17 38 18.39	101 59 11.5
		Fortuna 19	
1921			
Nov. 23	9 38 43.42	1 47 53.60	79 30 7.4
25	9 30 40.08	1 47 12.26	79 35 41.4
		Massalia 20	
1921			
Mars 8	9 5 58.81	8 9 59.86	70 57 4.5
9	2 1.76	10 1.72	56 37.8
12	8 50 34.91	10 21.56	55 56.9
15	39 27.35	10 59.94	56 16.3
19	25 2.72	12 49.12	....
21	8 18 1.51	8 13 9.86	70 59 43.7

Observatoire National de Besançon, Besançon, France, May 5, 1923.

CONTENTS

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THE GENERAL ORBITS OF THE ASTEROIDS OF THE *TROJAN* GROUP,

By ERNEST W. BROWN.

1. The problem of the motion of the asteroids which circulate round the *Sun* at the same mean distance as *Jupiter* and which oscillate about the positions differing by 60° heliocentric longitude from *Jupiter*, presents so many points of mathematical and mechanical interest, that a general explanation of certain features of the motion and of the methods adopted to obtain a solution of the problem may not be out of place, now that the theory has been completed. It is hoped also that this descriptive account will assist in making clear the detailed theory to be published in Vol. 3 of the *Transactions of the Yale Observatory* which, in spite of many efforts at clarification, is still quite complicated.

The object of the memoir is two-fold. I desired to carry the developments sufficiently far so that they could be used for comparison with observation and prediction with nearly the accuracy obtained at present by observation and to indicate how they could be continued to any required degree of accuracy. Also, as we have but little knowledge of the stability of our planetary and satellite systems except that derived from the actual developments, it was hoped that some idea might be gained as to whether the stability of motion of these asteroids differed essentially from that of a major planet or from that of other well known groups of asteroids. The gaps in the distribution of the latter may indicate some kind of instability but so far, mathematical investigation has failed to reveal it. Essential differences between the motions of the asteroids of the *Trojan* group which seem to be stable, and those of other groups whose mean motions should have exact or approximate commensurability with that of Jupiter, but which have no representatives, may possibly reveal the direction in which the instability, if it exists, should be sought.

2. After trials of different methods, that which appeared to be best capable of full development was one which involved the use of the true longitude of the asteroid in its orbit as the independent variable. This variable has been but little used since LAPLACE adopted it for his exposition of the lunar theory, partly perhaps because the development of the disturbing function for planetary theories appeared to be very troublesome and partly because tabulation with respect to the time was needed for purposes of prediction, necessitating a final transformation. It now seems as if neither of these objections rests on very secure foundations. Although the development of the disturbing function is easier in the case of the *Trojan* group than in other cases of planetary motion, there seems to be no reason why the methods adopted for this group should not be carried out for any other planet with no more labor than is necessary for developments in terms of the time. As for tabulation, this can be made with respect to the true longitude as easily as with respect to the time and there is no additional difficulty in comparing with observation: we simply tabulate the time, radius vector and latitude at equidistant values of the true longitude, instead of the true longitude, radius vector and latitude at equidistant values of the time. For asteroid prediction, there is scarcely any difference, since in general only a few positions are computed near each opposition and these can with a little final interpolation be put into the latter form if desirable. However, in the case of the *Trojan* group, a method was found (No. 29 below) which made the final transformation so easy, that the coördinates are obtained in both forms, the theory being mainly carried through with the true longitude as independent variable.

One of the general advantages of the use of this variable is due to the fact that the long period terms which are ordinarily present in the arguments of the short period terms, being taken there through the mean longtiude, are here automatically included through the presence of the true longitude in these terms, thus saving troublesome approximations, or the use of de-

vices such as these adopted by GYLDÉN. In the case of the *Trojan* group, the general convergence along powers of the disturbing force seems to be rather more rapid so far as the developments have been carried: this indication was obtained during the transformation to the time as independent variable.

3. LAPLACE uses the equations for the inverse of the radius vector, the longitude in the plane of reference and the latitude above this plane. Instead of the latter two coordinates I adopt the longitude in the orbit, the inclination of the orbit to that of *Jupiter* and the longitude of the node. But since the disturbing function and all the equations of motion can be expressed in terms of $\cos i$ ($\sin i$ being absent), the function $\Gamma = 1 - \cos i$ is used instead of i.

The principal advantage of the independent variable v is found in the equation for u the inverse of the radius vector, which takes the form

$$\frac{d^2u}{dv^2} + u = \text{const.} + \text{perturbations},$$

and is therefore integrated without difficulty even when we include certain perturbational terms in the left-hand member — a property which is necessary for the *Trojan* group.

For elliptic motion, the solution is

$$u = \{1 + e\cos(v - \varpi)\} \div a(1 - e^2)$$

and this suggests the general form $u = A(1 + E)$, where we so choose A that E shall only contain terms which have approximately the period of the true (or mean) anomaly. The form of the equation of motion (S1) suggested, however, that a better substitution would be to put $u = pq(1 + E)$ where $q = 1/h^2$, h being the areal velocity and to so determine p that E shall have terms of the required form, i.e., that p shall have no such terms. The equations for E, p are similar to that for u, but the equation for p gives rise to no small divisors, while that for E takes care of the long period variations of the eccentricity and longitude of perihelion. The variations of the mean longitude and mean motion are mainly determined by the equations for q, t, the chief function of p being that of keeping E clear of other short period variations.

The method therefore gives results somewhat parallel to those furnished by the methods which use the equations for the variation of the elliptic elements. But it has some advantages over the latter. The somewhat rigid form imposed by the requirement that the coordinates and velocities shall have the same form in disturbed and undisturbed motion leaves us little freedom as to methods of approximation and it is difficult to include terms of higher orders in the first approximation. With the present form of the equations we can choose our intermediate orbit at will and approximate to the complete solution in various ways. We can also substitute numerical values of the various parameters from the outset.

4. The *Trojan* group has a property which renders this method particularly useful. There is only one fundamental short period, that of the revolution of the asteroid or of *Jupiter* round the *Sun*, all other periods being long in comparison, the shortest of the latter — that of the libration — being about twelve times the period of *Jupiter*. In the ordinary planetary theory there are two fundamental periods which in general are of the same order of magnitude, and there is no such sharp distinction between long and short periods. Satellite problems in general show the same sharp distinction. In them the disturbing force is relatively much greater so that we are able to gain added advantage in being able to include higher powers of it from the start. I have, in fact, tried the method on *Jupiter* VIII and have obtained a first approximation to its orbit which appears to be sufficiently good to warrant continuation.

5. From the mechanical point of view, the chief feature of the motion of an asteroid of the *Trojan* group is due to resonance. *Jupiter* has so large a mass in comparison with that of an asteroid that its motion is practically unaffected by the latter and all the effects are exhibited in the asteroid only. The main property of a celestial system which has a natural period very close to that of a disturbing force is that when the periods are sufficiently close they become exactly the same. There is then an oscillation, usually termed a libration, about this mean position having an amplitude and phase which are arbitrary, that is, which depend on the initial conditions. There are several examples of this in the solar system but, besides the well-known case of the rotation of the moon about its axis, no other, except in the asteroids of the *Trojan* group, where the disturbing force has the period of revolution of the body, so as to become the controlling factor.

6. A second feature is due to the fact that the asteroid is compelled to follow *Jupiter* not only in its mean motion but also in its elliptic orbit, although this does not prevent the asteroid from having also an elliptic orbit of its own, so to speak. Now the attraction of *Jupiter* enters only into the equations of motion with the ratio of the mass of *Jupiter* to the mass of the *Sun* as a factor. It follows that if we are to have terms in the coördinates of the asteroid free from this factor, it must occur as a divisor during the process of solution. This is quite easily dealt with when the

"proper" eccentricity, the inclination and the amplitude of the libration are zero, for then we have an exact solution of the equations of motion. But when these parameters are not zero, the forms of the equations seem to indicate that there is no way of avoiding in some form this division by m. In the ordinary planetary theory, terms with divisors of this order can be well expressed as secular changes; here such a method would render the expressions useless in a short time.

7. The amplitude of the libration appears in the longitude free from any small factor and in general it is of the same order of magnitude as the eccentricities. Further, the expansions take place along powers, not of the mass, but of the square root of the mass of *Jupiter*. Hence, instead of the usual three parameters, — the eccentricities and inclination with the addition of a small parameter, the mass of the disturbing planet, we have five parameters which are in general of the same order of magnitude. But I have been able to reduce nearly all the sensible terms to a double expansion, by making use of various properties of the motion, one parameter being the square root of the mass and carrying with it without actual expansion the series representing the intermediate orbit (No. 11), and the other a combination of the two eccentricities and the intermediate orbit (No. 17). Most of the effects of the inclination are included at the outset, also without expansion in powers of Γ (No. 9). The remaining terms are quite small and of short period having the mass of *Jupiter* and one of the eccentricities as factors.

THE EQUATIONS OF MOTION

8. Let v, v' be the true heliocentric longitudes in their orbits of the asteroid and *Jupiter*; r, r' their distances from the *Sun* with the mean distance of *Jupiter* as unit; θ, the longitude on *Jupiter's* orbit of the node of intersection, and i, the inclination to one another of the orbital planes, that of *Jupiter* being considered as fixed. Let t denote n' (time) $+ \epsilon'$ where n', ϵ' denote the mean motion and mean longitude at epoch of *Jupiter*. Then with

$$u = \frac{1}{r}\,,\ D = \frac{d}{dv}\,,\ \Gamma = 1 - \cos i,$$

I obtain the equations in the following forms.

For the motion in the plane of the orbit:

$$D^2 u - \tfrac{1}{2}\,DuDq - DuD\log(1 - \Gamma D\theta)$$

$$+ \left(u - q - q\,\frac{\partial R}{\partial u}\right)(1 - \Gamma D\theta)^2 = 0, \tag{8·1}$$

$$Dq = -\frac{2q^2}{u^2}\,(1 - \Gamma D\theta)\,\frac{\partial R}{\partial v}\,, \tag{8·2}$$

$$Dt = \frac{q^{\frac{1}{2}}}{u^2}\,(1 - \Gamma D\theta), \tag{8·3}$$

where q is an auxiliary variable which may be defined as the inverse of the square of the areal velocity in the orbit.

For the motion of the plane of the orbit: —

$$D\theta = \frac{q}{u^2}\,(1 - \Gamma D\theta)\,\frac{\partial R}{\partial \Gamma}, \tag{8·4}$$

$$\Gamma q^{-\frac{1}{2}} = \text{const.} - \int (1 - \Gamma D\theta)\,\frac{q}{u^2}\,\frac{\partial R}{\partial \theta}\,dv, \tag{8·5}$$

The disturbing function R is put into the form

$$R = m\left(\frac{1}{\Delta} + \tfrac{1}{2}\,\frac{\Delta^2}{r'^3} - \frac{1}{r} - \tfrac{1}{2}\,\frac{r^2}{r'^3}\right),\ \Delta^2 = r^2 + r'^2 - 2rr'\mu,$$

where m is the ratio of the mass of *Jupiter* to the sum of the masses of *Jupiter* and the *Sun*, and

$$\mu = \cos(v - \theta)\cos(v' - \theta) + \cos i\sin(v - \theta)\sin(v' - \theta)$$

$$= (1 - \tfrac{1}{2}\,\Gamma)\cos(v - v') + \tfrac{1}{2}\,\Gamma\cos(v + v' - 2\theta), \tag{8·6}$$

9. The *Trojan* group is defined by the relation

$$v - v' = \pm 60^\circ + \text{periodic and constant terms.}$$

If we neglect the eccentricities and inclination, these periodic terms constitute the chief part of the libration and are of long period. It follows that the terms of lowest order with long periods produced by the second term of μ in (8·6) will be at least of the fourth order with respect to the eccentricities and inclination and can be neglected in the early approximations, and the short period terms are small. If then we alone neglect those parts of R which contain the angle θ, we shall be retaining nearly all the effects of the inclination, the equation (8·5) for Γ will reduce to

$$\Gamma q^{-\frac{1}{2}} = \text{const.} = \gamma,$$

and v, v' will only occur in the equations of motion in the form $v - v'$.

It is later shown that the principal part of q is given by $q = 1 + \frac{2}{3}\,D\tau$ where τ is the librational portion of $v - v'$ and is of long period, and that $D\tau$ has as factors $m^{\frac{1}{2}}$ and the amplitude of the libration, so that we can approximately replace Γ by $\gamma\,(1 + \frac{1}{3}\,D\tau)$, — a result which permits us to substitute the numerical value of γ at any stage of the process.

10. The general plan is one of approximation along powers of the eccentricities, the first approximation to

the intermediate orbit being obtained by neglecting these parameters. The terms depending on the first powers of the eccentricities are then computed. It is next shown that *all short period terms depending on powers of the eccentricities higher than the first can either be deduced immediately from the formula for motion in an ellipse or have m as a factor*, the latter thus having very small coefficients. An exception to this statement must be made for the terms depending on the third, fifth, ... powers of the eccentricites which should be treated as additions to those depending on the first powers when they have the same period, but these additions are shown to be quite small and easily included.

The long period terms depending on even powers of the eccentricities are treated as additions to the intermediate orbit and from a second approximation to it.

THE INTERMEDIATE ORBIT

11. It is well known that the principal part of the period of the libration is $2\pi : \nu n'$ where $\nu^2 = 27m : 4$. Thus in the intermediate orbit the operator D produces the factor $m^{\frac{1}{2}}$. Let us neglect the eccentricites. Then the definition of q and equation (8·2) show that $q - 1$ has the factor $bm^{\frac{1}{2}}$ where b is the main part of the amplitude of the principal term of the libration. It follows from (8·1) that $u - 1$ has the same factor and, if we put $u = pq$, that p is determined to the order m^2 inclusive by the equation

$$p = 1 + \frac{\partial R}{\partial u} - D^2 q.$$

We therefore have

$$\frac{\partial R}{\partial u} = \left(\frac{\partial R}{\partial u}\right)_{u=1} + (u-1)\left(\frac{\partial^2 R}{\partial u^2}\right)_{u=1},$$

and similarly for other derivatives of R. By proceeding in this manner with u, Γ, we reduce R and its derivatives to derivatives of R which contain only the single variable $\tau = v' - v$.

With the help of the Jacobian integral, the equation for τ is finally reduced to the form

$$x^2\{1 - \tfrac{5}{9}x^{-2}\}(1 + R'') = -6R_0 + R' + \text{const.}, \quad (11·1)$$

$$x = D\tau,$$

or, integrating, to

$$t = \text{const.} + \int \frac{(1 + R'')^{\frac{1}{2}}}{(-6R_0 + R' + \text{const.})^{\frac{1}{2}}}\,d\tau, \quad (11·2)$$

where

$$R_0 = m\left(\frac{1}{\Delta} + \frac{1}{2}\Delta^2 - \frac{3}{2}\right), \quad \Delta^2 = 2 - (2 - \gamma)\cos\tau; \quad (11·3)$$

R'', R' are functions of the derivatives of R; R'' has the factor m and R' the factor m^2 or $m\gamma^2$, and the equation (11·1) is correct to the order m^2 or $m^{\frac{3}{2}}\gamma^2$ inclusive. From the point of view of observation this equation includes all powers of m, γ which will give sensible terms for many centuries from the epoch.

The terms dependent on the squares and fourth powers of the eccentricities are later shown to be included by the addition of a function $-6R_2'$ to R', which, like R', R'', R_0, is a function of the single variable τ.

A remarkable property of (11·1) is the absence of odd powers of $m^{\frac{1}{2}}$ from R_0, R', R'', R_2' to the order m^2.

12. In order to perform the integration of (11·2), use must be made of the assumed property of τ, namely that it oscillates between certain limits, so that the denominator of the integrand must have the same property. As this denominator vanishes at the limits it is best to get rid of the infinities of the integrand by a change of variable. I put

$$\Delta^2 = 2 - (2 - \Gamma)\cos\tau = d\,(1 + b\cos\phi), \quad (12·1)$$

where ϕ is an angle which makes complete revolutions and d, b are constants. Here b is to replace the arbitrary constant present in the denominator. The well-known properties of integrals defining periodic functions require that $-6R_0 - 6R_2' + R' +$ const. shall have $\sin^2\phi$ as a factor; as $d\tau$ contains the factor $\sin\phi$, this latter function can be divided out and we shall have an integrand which is never infinite as long as b is sufficiently small. The condition determines d in terms of b.

I shall omit here the various devices by means of which these operations are actually carried out and by which the integrand is expressed as a FOURIER series with argument ϕ, and then integrated so as to obtain

$$\phi = \psi + a_1\sin\psi + a_2\sin 2\psi + \ldots,$$

$$\psi = \nu t - \tfrac{5}{9}\tau + \text{const.}$$

Thence, by reversion of series and by the use of (12·1), τ is finally obtained in the form

$$\tau = \pm 60^\circ + \tau_0 + \tau_1\cos\phi_0 + \tau_2\cos 2\phi_0 + \ldots$$

$$+ \tau'_1\sin\phi_0 + \tau_2'\sin 2\phi_0 + \ldots,$$

$$\phi_0 = \nu t + \nu_0.$$

In this series, $2\pi/\nu n'$ is the period, ν_0 the arbitrary phase; τ_1 has the factor b and may replace b as the constant of amplitude; τ_0 is of the order of the squares of the eccentricities, the inclination and b; τ_i $(i>0)$ has the factor b^i; τ_1' is of the order $bm^{\frac{1}{2}}$ and τ_i' $(i>1)$ has the factor $b^i m^{\frac{1}{2}}$. The principal part of τ is therefore the cosine series. For application to any member of the group, cases have been kept in mind where b may be as great as .3: the principal part of τ_1, is $2b\sqrt{3}$. With this value of b, it is necessary to go as far as τ_5 or τ_6 in order to obtain τ to $10''$, the limit of accuracy aimed at throughout.

13. The determination of τ has been made on the assumption that b, γ might have rather large values. It was found possible, however, to carry out an expansion in powers of b, γ and the eccentricities as far as the third powers inclusive. This will serve well for computation when the parameters are all small but is mainly required in finding first approximations to the constants of the theory from an observed osculating orbit and in correcting those constants when the given elements are changed.

I find

$$\tau_0 = \frac{3\sqrt{3}}{8}\tau_1^2 - \frac{\sqrt{3}}{6}\gamma + \frac{29\sqrt{3}}{24}\eta^2 + \frac{5}{2}\alpha,$$

$$\tau_2 = -\frac{\sqrt{3}}{8}\tau_1^2, \quad \tau_3 = \frac{5}{64}\tau_1^3,$$

$$\nu^2 = \frac{27}{4}m\left(1 - \frac{3}{8}\tau_1^2 - \frac{4}{3}\gamma + \frac{43}{24}\eta^2 + \frac{7}{2}\beta + \frac{31\sqrt{3}}{12}\alpha\right).$$

where

$$\beta = e'^2 + \eta e'\cos(\varpi_0 - \varpi' \mp 60^\circ),$$

$$\alpha = \eta e'\sin(\varpi_0 - \varpi' \mp 60^\circ),$$

η, ϖ_0 being defined as in No. 15: the secular motion of ϖ may be included with ϖ_0. The double sign refers to the two equilibrium positions.

THE DETERMINATION OF E

14. We neglect powers of the eccentricities beyond the first but retain terms in the equations of motion as far as $m^{\frac{3}{2}}$. Since a divisor of order m appears in the terms factored by e', it would seem that our results would be only correct to $m^{\frac{1}{2}}$. Strictly speaking this is true. But it appears that the only portion which is not obtained correctly to order m can be merged, with an error much smaller than our needs, in the arbitrary constant of eccentricity, so that the error is, in the applications, allowed for in the process of deducing the constant of eccentricity from the observed position of the asteroid.

The equation for E is reduced to the form

$$D^2(QE) + (1-P)QE = -\lambda e'\cos(v \mp 60^\circ - \varpi')$$
$$- \mu e'\sin(v \mp 60^\circ - \varpi'), \qquad (11)$$

where Q, P, λ, μ are functions of τ, $D\tau$ obtained from the intermediate orbit, $Q-1$ having the factor $bm^{\frac{1}{2}}$ and P, λ, μ the factor m. All these functions are FOURIER series with argument $\phi_0 = \nu v + \nu_0$.

The equation is of the well-known linear type with periodic coefficients and may be solved by any one of the known methods. But the solution may be obtained much more easily by making use of the properties of P, namely, that it has a small factor and that ν is small compared with unity.

15. When $e' = o$ it is known that the solution is of the form

$$QE = \Sigma a_i\cos(v - \varpi_1 v - \varpi_0 + i\phi_0)$$
$$+ \Sigma a_i'\sin(v - \varpi_1 v - \varpi_0 + i\phi_0),$$

where $i = 0, \pm 1, \pm 2, \ldots$, ϖ_1 being a determinate and ϖ_0 an arbitrary constant; the other arbitrary is a_0. The periods of all these terms therefore differ but little from 2π. Hence I put

$$D = D_1 + D_0,$$

where D_1 acts on v only in its explicit form and D_0 on the portions which contain v implicitly only, that is, on ϕ_0, P, λ, etc. Hence D_0 acting on any of these functions produces the factor ν and $D_1^2 + 1$ produces zero.

The equation may therefore be written

$$(2D_1D_0 + D_0^2 - P)QE = 0.$$

By assuming that the solution is

$$QE = e_1\cos(v - \varpi)$$

and remembering that D_0^2, P produce the factor m, we easily obtain by continued approximation,

$$\varpi = \frac{1}{2}D_0^{-1}P + \frac{1}{8}D_0^{-1}P^2 - \frac{1}{8}D_0P \ldots + \varpi_0,$$

$$e_1 = \left(1 + \frac{1}{4}P + \frac{5}{32}P^2 - \frac{1}{8}D_0^2P \ldots\right)\eta,$$

the terms being written down as far as the order m^2 inclusive. To the order m, which is sufficient for the theory we have $\varpi = -D_0^{-1}P + \varpi_0$, $e_1 = \eta(1 + P)$. The secular part of ϖ arises from the constant term in P and its principal portion is $27mv/8$.

16. Denote the right hand member of (14·1) by P' and put $y = QE$. Then the particular integral is obtained from the equation

$$2D_0D_1y = P' + yP - D_0^2y,$$

or from

$$\begin{aligned} 2D_0D_1(y - y_0) &= P' + y_0P \\ &+ (y - y_0)P - D_0^2(y - y_0) \end{aligned} \qquad (16·1)$$

where

$$y_0 = Ke'\cos(v \mp 60° - \varpi') + K'e'\sin(v \mp 60° - \varpi'),$$

K, K' being constants to be so determined that in the expansion of λ, μ, P, in FOURIER series with argument φ_0 the expressions

$$-\lambda + KP, \; -\mu + K'P$$

shall contain no constant term.

This introduction and definition of y_0 are necessary in order to avoid the occurrence of secular terms in the solution and it is in the determination of K, K', that the division by the factor m takes place.

For a first approximation we neglect the last two terms of (16·1) and obtain

$$\begin{aligned} y - y_0 &= \tfrac{1}{2}D_0^{-1}D_1^{-1}(P' + y_0P) \\ &= -\tfrac{1}{2}D_0^{-1}(D_1P' + y_0D_1P); \end{aligned} \qquad (16·2)$$

with this, a second approximation is easily found. The effect of the operator D_0^{-1} is now to produce only periodic terms and the small divisors arising in the integration are of the order $m^{\frac{1}{2}}$, so that the right hand member of (16·2) has the factor $m^{\frac{1}{2}}$.

The principal part of y is therefore y_0. Since the principal part of λ is P and since the constant part of μ has the factor b/m, we have $K = 1$, $K' = 0$ approximately, — a result which shows how the eccentricity of *Jupiter* is introduced into the motion of the asteroid free from the factor m.

17. The complete solution of (14·1) may be written

$$E = e\cos(v - \varpi''), \qquad (17·1)$$

where e, ϖ'' are long period functions of v, and constitute what may be called the "effective" eccentricity and longitude of perihelion of the asteroid. It is with this value of E that the disturbing function is developed in order to obtain the terms dependent on the squares and higher powers of the eccentricities, and with it the equation for the time is integrated. When we substitute the development in the equations for p, q, E, we see at once that the remaining short period terms have the factor m, no small divisors being present, so that their calculation is a simple matter.

A further saving is effected by making use of the fact that Rr' (or Rr) is a function of the coördinates in the forms $r'u$, $v - v'$ only so that the use of e_1, ϖ, where

$$e_1 \begin{matrix}\cos\\ \sin\end{matrix} \varpi_1 = e \begin{matrix}\cos\\ \sin\end{matrix} \varpi'' - e' \begin{matrix}\cos\\ \sin\end{matrix} (\tau + \varpi^1),$$

instead of e, ϖ'' is suggested. This has the additional advantage that when b is neglected e_1, ϖ_1 reduce to η, ϖ — the real eccentricity and longitude of perihelion of the asteroid.

17*a*. We are now in a position to calculate R_2 (No. 11) the portion additive to R_0 depending on even powers of the eccentricities required to find τ. For this, it is first proved that to order $m^{\frac{1}{2}}$ the equation

$$x^2 - \tfrac{5}{9}x^3 = \text{const.} - 6R_0 - 6R_2$$

is sufficient provided terms of this order are neglected in the right hand member (they vanish automatically); we therefore neglect the variation of e, ϖ''. By somewhat involved processes, it is next shown that

$$\frac{d}{d\tau}(R_0 + R_2) = \frac{\partial R}{\partial v} + \frac{\partial R}{\partial u}\frac{du}{dv} = \frac{d}{d\tau}\left(R\frac{dt}{dv}\right),$$

where, after expansion we neglect all the short period terms. These forms include all powers of both eccentricities. But the long period part of Rdt/dv expressed in terms of v is none other than the long period part of R expressed in terms of t. We therefore develop R by means of the elliptic formulae in terms of the time, and $R_0 + R_2$ is then the portion of it which is independent of the short period terms. This portion contains the eccentricities only as powers and products of

$$e^2,\; e'^2,\; ee'\cos(\varpi'' - \varpi' - \tau),\; ee'\sin(\varpi'' - \varpi' - \tau),$$

the coefficients depending only on τ and having m as a common factor.

18. The remaining computations to obtain Γ, θ and the terms having θ in their arguments present no points of special interest. In obtaining the motion of the node, however, it is at once seen that its secular part has the factor m multiplied by the squares of the other parameters, instead of the simple factor m as in the ordinary planetary theory. It is also easily seen that the portion of this secular motion produced by the direct action of *Saturn* is nearly the same as that produced by this planet on the motion of *Jupiter*. Hence *Jupiter compels the asteroid to have nearly the same secular nodal motion as itself.* It is possible that for some asteroids of the group the principle of close resonance may again come into action here, namely, that the secular motions of the two nodes become exactly the same with the libration of the asteroid's node about this mean relative position; but the investigation of this demands developments more extensive than those of the memoir and would lead too far from the objects immediately in view.

The secular motion of the perihelion has no such property. Its principal part is $27mr$ 8 which is much larger than the part produced in the perihelion of *Jupiter* by *Saturn*, the latter being appreciably the same for the asteroid and *Jupiter*.

FINAL FORMS OF THE EXPRESSIONS FOR THE COORDINATES

18. So far as the actions of *Jupiter* and the *Sun* only are concerned, the final forms are shown by the following expressions.

The time $-n't+\epsilon'$ in the usual notation — is given by

$$t = v - \tau - (1 - D\tau)\,\epsilon_r + \delta t.$$

In this expression, τ contains the long period librational terms, Er is the equation of the centre in terms of the eccentricity e and the true anomaly $v - \varpi''$ (No. 17), and δt contains terms of short period having as factors both m and powers of the eccentricities and of γ. The degree of accuracy is such that if η is not much greater than ·1, $i < 30°$, $b < ·3$, the longitude of the asteroid should be obtainable to about $10''$ within at least a century from the epoch, it being assumed that the data are obtained with the necessary accuracy.

That the result should be capable of expression in so simple a form is remarkable. It is shown in No. 29 that when the longitude is expressed in terms of the time, neglecting δt and some very small terms, the result is nothing but the formula for elliptic motion with mean longitude $t + \tau$, eccentricity e, longitude of perihelion ϖ'' in which t is substituted for v in τ and $t + \tau$ for v in the expressions for e, ϖ''. With these limitations the errors are of the order of one or two minutes of arc.

19. The variables p, q are given by expressions of the form

$$p = 1 + \delta p_0 + p_2,$$

$$q(1 - e^2) = 1 + \tfrac{2}{3}\,D\tau + \delta q_0 + q_1 + q_2,$$

where δp_0, δq_0 are long period terms having the factor m; p_2, q_1, q_2 also have the factor m and are of short period, the suffixes denoting additional factors depending on the eccentricities and inclination.

The principal part of Γ is given by $\Gamma = \gamma q^{\frac{1}{2}}$, the remaining terms having the factor $m\gamma$. From this equation combined with $\Gamma = 2\sin^2 \tfrac{1}{2} i$ we obtain i.

The principal part of θ is obtained by integrating the equation

$$-\ 1\ D\theta = (Dq_0\quad q_0)\cot\tau,$$

where q_0 is the long period part of q. From this equation we deduce the fact that the secular part of θ has the factor mb^2 (No. 18) and that the principal periodic term has the factor $bm^{\frac{1}{2}}$. Since θ has its greatest effect on the latitude which has $\gamma^{\frac{1}{2}}$ as a factor, the actual effect of the variation of θ is quite small.

THE EFFECTS PRODUCED BY SATURN

20. The attractions produced by the planets other than *Jupiter* are divided into the direct and indirect, the latter being the effect produced on the motion of the asteroid through the variations of the motion of *Jupiter* from an elliptic orbit. Since the only planet which can produce any sensible effect is *Saturn*, although the general theorems stated below apply to the actions of all the planets, we shall confine our attention to *Saturn* alone. The direct action of *Saturn* introduces terms into the equations of motion which have the mass of *Saturn* as a factor while the indirect terms contain the product of the masses of *Jupiter* and *Saturn*; in spite of these facts, the latter produce changes in the longitude in general larger than the former. The investigation of both problems is difficult because in neither case can we neglect the action of *Jupiter* as is ordinarily done in finding the principal perturbations of one planet by another.

The method adopted consists in finding the equations for the variations of the coördinates when we retain the principal terms due to the action of *Jupiter*, and then applying the results to the various terms produced by the action of *Saturn*. If we are not to be landed in a maze of complicated formulæ, it is necessary to make a careful examination of the terms which will or will

not produce sensible effects. In the following paragraphs I shall only give the comparatively simple results which such an examination has furnished.

THE DIRECT ACTION OF SATURN

21. The most important part of the action of *Jupiter* occurs in the equation which gives the time in terms of the true longitude; this, in the method of the variation of arbitrary constants, corresponds to the equation giving the mean longitude in terms of the time. If $\delta\tau$ be the portion add to τ due to the action of *Saturn*, the principal part of the equation may be written

$$D^2\delta\tau + (\nu^2 + y)\,\delta\tau = A \sin (sv + s'\tau + s_0), \qquad (21{\cdot}1)$$

where the right hand member is a term arising from the action of *Saturn* and y is a Fourier series with argument ϕ_0 (No. 12) which vanishes with b, the eccentricities and the inclination. The portion τ is introduced into the right hand member because the mean longitude of *Saturn* is given in terms of t and the transformation $t = v - \tau$ must be applied.

In this equation it is to be noticed that ν^2, y *have the factor* m; in the ordinary planetary theory taken to the same order, the constant part of $\nu^2 + y$ is zero.

The integral of (21·1), if in a first approximation we neglect y and the variable part of τ, is

$$\delta\tau = \frac{A}{\nu^2 - s^2} \sin (sv + s'\tau + s_0)$$

The complete integration when y, τ are not neglected is given in No. 24 below. There are three cases to consider according as s/ν is large, small, or nearly unity. The first case, being that of short period terms in which ν/s may generally be neglected, is the same as in the usual theory and needs no further remark.

22. When s is small compared with ν, the divisor is approximately ν^2; in the ordinary theory it is s^2. Hence inequalities of very long period in the longitude do not have coefficients which tend to become very large as the period increases. The theory therefore shows that *the action of Jupiter prevents the asteroid from having any very large inequalities of very long period due to the direct attractions of the other planets.* In a similar way we can show that secular and pseudo-secular terms cannot arise from this source. The corresponding inequalities in radius vector are much smaller since in general they are proportional to the derivatives of the terms in longitude; they thus tend to vanish as the period lengthens.

23. The cases $s \pm \nu$ small (and with them the cases $s \pm i\nu$ small) compared with ν (see No. 24) are the only ones where very small divisors may arise. The general effect of such terms is to increase the amplitude of the libration. But the period of the libration is not independent of its amplitude. A general idea of what will happen can be deduced from the analogous case of the pendulum acted on by a force whose period is nearly equal to that of the pendulum. The oscillations increase in amplitude, but as they increase the period lengthens, and the resonance becomes less effective; in other words, the phase gradually changes and the oscillations diminish again, the cycle of changes being continually repeated. It may be regarded as a secondary libration superimposed on the primary libration. If the external force is large enough, the pendulum may have its motion temporarily or permanently changed to one of continuous revolution: in the motion of an asteroid of the *Trojan* group this would mean that the mean triangular configuration would no longer exist and we should regard the term as producing instability. An examination, however, of the attractions of the other planets reveals no terms which seem to be large enough to produce such a result.

24. The chief effect of the action of *Jupiter* on the perturbations produced by other planets can be shown quite briefly in another way which also serves to give a different view of the solution of the equation for the libration.

If we neglect all but the terms of lowest order in equation (11·1) and differentiate, we obtain

$$D^2\tau + 3\,\frac{\partial R_0}{\partial \tau} = 0, \qquad (24{\cdot}1)$$

where R_0 has the value (11·3). The solution of this equation is

$$\tau = \pm 60^\circ + \tau_0 + \tau_1 \cos \phi_0 + \tau_2 \cos 2\,\phi_0 + \ldots, \qquad (24{\cdot}2)$$

$$\phi_0 = \nu v + \nu_0,$$

in which the arbitrary constants may be taken to be τ_1, and ν_0. We might in fact obtain ν, τ_0, $\tau_2, \ldots$ by substituting this expression in (24·1) and, after expansion, equate to zero the coefficients of $\cos i\phi_0$.

What we need is the solution of

$$D^2\tau + 3\,\frac{\partial R_0}{\partial \tau} = A \sin (sv + s'\tau + s_0), \qquad (24{\cdot}3)$$

where the term on the right is due to the action of *Saturn*.

Suppose we find the addition $\delta\tau$ due to the presence of this term by the method of the variation of the arbitraries ν_0, τ_1 on the assumption that we can neglect squares of A. The equation to be solved is

$$D^2\delta\tau + 3\frac{\partial^2 R}{\partial\tau^2}\delta\tau = A\sin(s\nu + s'\tau + s_0) \quad (24\cdot 1)$$

When $A = 0$ two particular solutions of this equation are $\delta\tau = \partial\tau/\partial\nu_0$, $\delta\tau = \partial\tau/\partial\tau_1$. Following the usual methods, we obtain for the additions to ν_0 (or ϕ_0), τ_1 due to the right-hand member,

$$D\delta\tau_1 = \frac{A}{B\nu}\frac{\partial\tau}{\partial\phi_0}\sin(s\nu + s'\tau + s_0),$$

$$D\delta\phi_0 = -\frac{A}{B\nu}\frac{\partial\tau}{\partial\tau_1}\sin(s\nu + s'\tau + s_0),$$

where $B = \Sigma i\tau_i\,\partial\tau_i/\partial\tau_1$. These may be written

$$D\delta\tau_1 = -\frac{A}{B\nu}\frac{\delta}{\partial\phi_0}\cos(s\nu + s'\tau + s_0),$$

$$D\delta\phi_0 = \frac{A}{B\nu}\frac{\partial}{\partial\tau_1}\cos(s\nu + s'\tau + s_0).$$

After the insertion of the series for τ, the former of these equations shows that there is no term in $\delta\tau_1$, independent of the argument ϕ_0. Hence *a term of very long period due to the action of another planet does not produce a term of the same period in the amplitude of the libration.* This result is an extension of the theorem of No. 22 which merely showed that τ had no large term of very long period while this shows that the amplitude itself has no large variations of very long period.

It is true that A may contain τ, but the form of the disturbing function is such that the portions of A which contain τ have the additional factor $bm^{\frac{1}{2}}$ and that they are therefore very small.

This theorem and its extension may be regarded as the analogue, in the case of the *Trojan* group, of the well-known theorem concerning secular and pseudo-secular terms in the major axes of the ordinary planetary theory.

25. The analogy of a resonance with the period of the libration to the motion of a pendulum mentioned in No. 23 points towards the similar effects which may be produced in the orbits of other groups of asteroids whose mean motions are nearly commensurable with that of *Jupiter*. The *Trojan* group is unique amongst them in the fact that the principal part of the period of its libration depends only on the mass of *Jupiter*, the other parameters affecting this period to a comparatively small extent. If, therefore, with the present values of these parameters no large effects are exhibited, it is improbable that any such effects will be produced for very long periods in the past or future, if at all; in other words, the system, so far as the longitude is concerned, exhibits a high degree of stability. It is not so with the other groups: their libration periods are sensitive to changes in the eccentricities. As these periods are in general shorter than the changes of very long period in the eccentricities (those usually called secular), there is time for the resonance, when it occurs owing to changes of very long period in these eccentricities, to have a considerable effect on the libration. It is possible that an explanation of the gaps in the distribution according to period, of the asteroids between *Jupiter* and *Mars* may be found in this direction. The extent to which the approximations are usually carried does not and cannot reveal it because the terms in question have as a factor the product of the mass of *Jupiter* and that of another planet. They must be treated not as small additional perturbations additive to the effects produced by *Jupiter*, but as a portion of the four-body problem involving the *Sun*, *Jupiter*, the other disturbing planet and the asteroid, just as we have been compelled to treat them in the case of the *Trojan* group.

26. The direct effects produced by *Saturn* on the eccentricities and inclinations of asteroids of the *Trojan* group by long-period terms are in general similar to those of the ordinary theory, but one case deserves mention, — the great inequality, which has as argument five times the mean longitude of *Saturn* minus twice that of *Jupiter*, possesses a daily motion of its argument of about 4″ when we neglect the motions of the perihelia and nodes. The perihelion of an asteroid of this group has a daily motion of about 1″. Since the third multiples of the perihelia of *Jupiter*, *Saturn* and the asteroid appear in the principal terms, and since the motions of the two former are comparatively small, we have terms with approximate daily motions of 1″, 2″, 3″ giving periods and coefficients differing essentially from those which we should have obtained if we had neglected the motion of the perihelion of the asteroid. The corresponding perturbations of the eccentricity are of the order of 100″. But there are obviously terms of the fifth order with respect to the eccentricities and inclinations which have motions very near zero, indicating the fact that for some asteroids of this group, the eccentricities may vary between wide limits in the course of very long periods of time. Here a phenomenon peculiar to this group may occur. Too great

an eccentricity may bring the asteroid within the radius of action of *Jupiter*, that is, to a position where the attraction of *Jupiter* is greater than that of the *Sun*. What would then happen cannot be predicted since the present theory breaks down at such a place. We can say, however, that the future history would largely depend on the initial conditions, that is, on the values of the constants, and that the type of motion represented by this group would no longer exist. This appears to be the only way at present in which the stability of an asteroid of this group is threatened. Of course for observational purposes within many thousands of years such terms can be quite neglected since they are absorbed in the determination of the constants from observation.

27. For the actual calculation of the direct effect of *Saturn*, I have not developed the methods with the true longitude as independent variable, since with a few changes it is possible to make use of the extensive literal development of LEVERRIER for the action of *Saturn* on *Jupiter*, thus saving much time and labor. The principal change is from the ordinary equation giving the perturbations of the mean longitude to that represented by (24'1), and this is effected without difficulty after the change from the true longitude to the time as independent variable has been made. It is shown that in the development of the disturbing function, the mean longitude of the asteroid is to be replaced by $t + \tau_t$ where τ_t is the libration expressed in terms of the time, and that the eccentricity and longitude of perihelion are to be replaced by their "effective" values (No. 17) in which in general we can neglect the periodic terms depending on the argument ϕ_0. The presence in τ_t of periodic terms with the argument of the libration gives rise to a set of new terms which are taken care of by the method of No. 21.

THE INDIRECT ACTION OF SATURN

28. The principal part of the theory has been developed on the assumption that *Jupiter* moves in a fixed elliptic orbit. It is necessary to examine the manner in which the motion of the asteroid is affected by the deviations of *Jupiter* from such an orbit produced by the attractions of the other planets. The well-known results of the perturbations of *Jupiter* by *Saturn* show that these deviations are quite large, the coefficient of the great inequality in longitude being about 20′. In order to investigate them the fundamental equations given in No. 8 are changed by altering the dependent variables. The new variable t is n' (time) $+ \epsilon' +$ perturbations of the mean longitude of *Jupiter*, and the new variable u is the ratio of the mean distance of *Jupiter* with its perturbations to the actual radius vector of the asteroid. In order to make use of HILL's theory of *Saturn* and *Jupiter** for the perturbations of *Jupiter*, the changes are made in the Hansenian form, namely, as additions to the mean anomaly of *Jupiter* and to the logarithm of its disturbed radius vector. The resulting additions to the equations of motions are quite simple.

An examination of the solutions of the new equations shows what might have been expected, namely, that nothing is gained by including in the perturbations of *Jupiter* the terms of short period, so that the latter are left for later treatment. It is next shown that the equations reduce very nearly to their original forms if we add to the mean longitude of the asteroid, the same terms which have been added to the mean longitude of *Jupiter*. Thus *Jupiter impels on the motion of the asteroid its own inequalities of very long period in longitude* (including the pseudo-secular terms), the additional long period terms not so taken care of being comparatively small. The mean distance of the asteroid, however, does not carry the corresponding terms in the mean distance of *Jupiter*.

This theorem is proved only to the degree of accuracy to which the work is carried. It is probably exact for the perturbations of *Jupiter* whose periods are infinitely long, that is, for secular terms. It is certainly not exact for perturbations of finite period and is only approximately true for those whose period are long compared with the period of the libration and in particular, for the great inequality. Nevertheless, it takes care of so large a fraction of the long period terms that the portions which remain are easily calculated.

An interesting view of these terms of very long period is contained in the statement that there are terms in longitude with a given period depending on the product of the masses of *Jupiter* and *Saturn* in the equations of motion whose coefficients are much larger than the terms with the same period depending on the mass of *Saturn* only. For example, in the case of 588 Achilles, the "great" inequality due to the direct action of *Saturn* (which belongs to the latter class) is found to have a coefficient of less than 20″, while that portion due to the indirect action of *Saturn* (of the former class) has a coefficient of about 1200″. This result seems to be a peculiarity of the *Trojan* group which in several ways takes an intermediate place between ordinary satellite theory and ordinary planetary theory.

The only remaining important terms in the motion of *Jupiter* which have to be considered are those with periods nearly equal to that of *Jupiter*. These are inserted in the equation for E where they alone produce sensible terms and are finally expressed as changes in

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the eccentricity and longitude of perihelion of *Jupiter* but with smaller coefficients than in the motion of *Jupiter*.

TRANSFORMATION TO THE TIME AS INDEPENDENT VARIABLE

29. As stated earlier, this transformation is not necessary for the ordinary use made of the results of the theory. But the comparison of the formulae with the two variables is of some interest. The method itself, being of general application to planetary theory and quite simple to carry out, is reproduced here.

LAGRANGE has shown that if

$$y = Z + f(y)$$

where $f(y)$ contains a small factor, then y can be expressed in terms of z by means of the series

$$y = Z + f(Z) + \frac{1}{2!}\frac{d}{dZ}\left\{ f(Z) \right\}^2 + \frac{1}{3!}\frac{d^2}{dZ^2}\left\{ f(Z) \right\}^3 + \ldots \qquad (29{\cdot}1)$$

The final form of the equation for expressing the time in terms of the true longitude is

$$t = v - \tau - (1 - D\tau)E_r + \delta t, \qquad (29{\cdot}2)$$

where τ is the libration expressed as a periodic funtion of v, $D\tau = d\tau/dv$; E_r is the equation of the centre expressed in terms of the eccentricity e and the true anomaly $v - \varpi''$ (see No. 17); and δt consists of terms having the factor m and being at least of the first order with respect to the eccentricities and inclination. It follows from the earlier work that De, $eD\varpi''$ have the property just stated for δt, and that $D^i\tau$ has the factor $bm^{i/2}$.

Denote the variable present in τ by the functional form $\tau(v)$ and write (29·2) in the form

$$v - \tau_r + \delta t = t + \tau(v) - E_r D\tau(v),$$

or neglecting $\delta t \cdot D\tau$ and derivatives of τ higher than the second,

$$v - E_r + \delta t + \tfrac{1}{2}E_r^2 D^2\tau$$
$$= t + \tau(v - E_r + \delta t + \tfrac{1}{2}E_r^2 D^2\tau).$$

Put the left member of this equation equal to $t + \tau_t$, so that the equation becomes

$$t + \tau_t = t + \tau(t + \tau_t).$$

This is ready for the application of (29·1) and gives

$$t + \tau_t = t + \tau(t) + \frac{1}{2!}\frac{d}{dt}\left\{ \tau(t) \right\}^2 + \ldots,$$

which exhibits τ_t as a function of t and shows that it depends only on τ and its derivatives.

The equation

$$v = t + \tau_t + E_r - \delta t - \tfrac{1}{2}E_r^2 D^2\tau(v)$$

is ready for a second application of LAGRANGE'S theorem with

$$y = v, \quad Z = t + \tau_t, \quad f(v) = E_r - \delta t - \tfrac{1}{2}E_r^2 D^2\tau(v).$$

Suppose these values have been inserted. Let us again adopt the device of No. 15 by putting $D = D_i + D_o$, so that D_i acts only on v where it occurs in the form iv and D_o produces the factor $bm^{1/2}$ at least. Since we neglect terms factored both by m and the cubes of the eccentricities we can write

$$D^n E_r^{n+1} = D_i^n E_r^{n+1} \text{ for } n > 2.$$

Now the expression

$$E_t = E_r + \frac{1}{2!}D_i E_r^2 + \frac{1}{3!}D_i^2 E_r^3 + \ldots, \quad v = t + \tau_t,$$

is the formula derived by the use of LAGRANGE'S theorem for the equation of the centre expressed in terms of the mean anomaly $t + \tau_t - \varpi''$ and eccentricity e. The remaining sensible terms are easily selected.

We obtain in this way

$$v = t + \tau_t + E_t - \delta t + \delta v,$$
$$\delta v = \tfrac{1}{2}D_o E_r^2 - \tfrac{1}{2}E_r^2 D^2\tau - D_i(E_r\delta t),$$

where in e, ϖ'', δt, δv we put $v = t + \tau_t$. Since all the terms in δv have m as a factor and are besides of the order of the squares of the eccentricities, we can put in the expression for δv.

$$E_r = 2e\sin(t + \tau_t - \varpi''),\ D = d/dt,\ \tau = \tau_t.$$

Thus the only *computation* needed in order to perform the transformation is that which is required to find τ_t, δv and this is quite simple: the terms in δv are always very small and the principal part of τ_t is that obtained by putting $t = v +$ const. in τ. The trans-

formations of Dt, p, q are made by similar methods and involve equally simple computations.

NUMERICAL APPLICATIONS

30. The actual computations necessary to obtain numerical formulæ ready for tabulation are neither long nor difficult if we are content with errors of the order of one or two minutes of arc in the heliocentric longitude within a century of the epoch, when the constants of the theory have once been obtained with the necessary accuracy. The additional computation necessary to reduce the error to $10''$ is about the same. The chief difficulty is the determination of the constant b from the observed data, and the approximations necessary to find it with the required exactness constitute a considerable part of the whole work. The labor of putting the calculations into workable shape has been so considerable that I have thought it worth while to give detailed instructions in the memoir for applying the methods to any asteroid of the group.

For illustration, the asteroid 588 Achilles was chosen, partly because a fairly good set of elements for it was available* and partly because a rather large value for b was indicated. The preliminary work has given a value for this constant of .094, with a range for τ from 55° to 68°, the constant term in τ being $61^\circ.5$. From a first approximation with an inferior set of observed elements, I obtained in 1912† a range of 50° to 72°; LINDERS‡ in 1908 from a preliminary set of elements obtained a range of $42^\circ.7$ to $77^\circ.3$. These differences sufficiently illustrate the necessity for an accurate theory and good observed elements.

The "proper" eccentricity η is .103 and longitude of perihelion at date 85°. Since ϖ' is 13° and e' is .048, we obtain the "effective" eccentricity .150 and longitude of perihelion 81°, which are not very different from the osculating elements. Since the perturbations of the inclination and of the node are small, the osculating values of these latter elements are not very different from their mean values at date.

These numerical results are provisional.

*By J. M. V. HANSEN, *Copenhagen Obs. Publ.*, No. 29.
†*M. N.* vol. 72, p. 617.
‡*Ark. K. Sv. AK. Stockholm*, Band 4, No. 20.

Yale University,
1923, May 31.

ON THE ACCURACY OF TIME DETERMINATION,*

By H. R. MORGAN.

[Communicated by CAPTAIN W. D. MACDOUGALL, U. S. Navy, Superintendent, U. S. Naval Observatory.]

Recent intercomparisons of wireless time signals show rather large variations in the time from one observatory as compared with that from others, and suggestions have been made that such variations may be due to the astronomical observations. Some of the results of investigations along this line, especially as bearing upon the performance of large instruments may be indicated.

The determinations of time from astronomical observations may be separated into two classes — provisional and definitive. When it is desired to send out a signal which itself indicates true time, such as required by business, commerce, and navigation, it becomes necessary to predict corrections to the standard clock from provisional observations and reductions for a few days, or even for a longer period depending upon the weather, and to set a transmitting clock as near as possible to true time. The determinations of time, in general, used for such purposes are quite provisional. With the smaller instruments an attempt is made to eliminate errors of collimation and clamp difference by reversal each night, errors of azimuth by observing stars both sides of the zenith, and errors of personal equation by using traveling wires. The larger instruments are reversed only occasionally or not at all. With these the collimation is determined by opposing collimators; the azimuth from observations of two or three pole stars, in some cases by intermediate use of meridian marks; and the clamp terms are neglected. Some of the instruments have traveling wires, and with others there are machines for determining personal equation. Smaller instruments use spirit levels and larger ones determine their levels over mercury. Among errors usually neglected in provisional work are those due to variation of azimuth, variation of personal equation, errors in star places and preliminary clock rates, and chronograph errors arising from adjustments of relays and varying battery currents especially as affecting the make-circuit relays introduced with the traveling thread micrometers, and finally errors in transmission and reception of signals. Errors in star places, systematic and accidental, are of

*Read before the 1923 meeting of the American Geophysical Union.

the order of $0^s.02$. Probably the best positions available now are those recently derived by PROF. EICHELBERGER, and published in the *American Ephemeris* 1925. These places are now being used at Washington.

In the definitive work azimuth and its variation are determined by means of meridian marks the positions of which are determined from large numbers of observations of circumpolar stars with an elimination of star place. These meridian marks are very stable, and errors in azimuth determinations are noticeably much smaller when they can be used. In the definitive reductions the personal equations are determined; the solutions for clock rate extend over longer periods; definitive positions of clock stars are used; examinations for clamp differences are made: and erratics in clock and chronograph systems studied. Corrections for such errors may be applied in longitude work if the provisional observations are so planned.

Large observatories are now equipped with modern self-winding clocks sealed in glass cases under constant pressure, and kept in clock vaults at constant temperature. An example of the running of such clocks is furnished by one of the clocks at the Naval Observatory in 1905 whose plotted clock corrections on 83 nights extending over a period of five months deviate less than $0^s.1$ from a straight line.

An examination, (*Astr. Jour.* No. 811), of the differences in clock corrections taken a number of hours apart on 839 nights from 1903 to 1921 shows that there is practically no daily variation in the clock corrections determined with the 9-inch transit circle at the Naval Observatory, and that the clocks have the same rate day and night.

An examination of the differences in clock corrections taken a number of hours apart on 2340 nights in the last 20 years, using results from both transit circles, shows that there is no certain variation in such corrections as large as $0^s.002$ depending upon the hour angle of the *Moon*.

As all observers find that the best of clocks occasionally change their rate unexpectedly, it is good practice to keep two or more clocks running and compared regularly. One of the Riefler clocks at the Naval Observatory varied $0^s.3$ from its normal in two days in March, and $0^s.5$ in two or three days in August 1921. Such erratics in the clock cause outstanding accidental errors in time signals, but they become known by subsequent observations.

The behavior of certain instruments is shown in what follows.

A comparison has been made of the definitive clock corrections taken about eight hours apart on the same night by different observers, or about fourteen hours apart on succeeding nights by the same observer, on 1026 nights from 1903 to 1921, with the 9-inch transit at the Naval Observatory. When corrected for personal equation, these clock corrections were reduced to the same time by means of adopted clock rates and their differences taken. There is but one difference exceeding $0^s.1$ in the 18 years, the average difference being $0^s.03$. Apparently observations on this instrument reproduce themselves within $0^s.03$ as far as accidental errors go. To examine for systematic errors also another comparison has been made, (*Astr. Jour.* No. 817), using clock corrections taken within a few hours of each other on the same night with the 9-inch transit and the 6-inch transit. During the period 1913.5–1918.5 clock corrections were determined nearly simultaneously on the two instruments on 397 nights. The differences in these clock corrections show marked discontinuities at each reversal of either instrument. The average change at 12 reversals of the 9-inch was $0^s.06$ with a variation of $0^s.03$ from this mean; and the average change at 19 reversals of the 6-inch was $0^s.12$ with a variation of $0^s.06$ from this mean. These clamp differences were taken only at times when one instrument was reversed and the other was not — the 6-inch was reversed more frequently than the 9-inch — and moreover they resulted from observations of equatorial stars only. After applying mean values for clamp differences there are but four of the 397 differences as large as $0^s.1$; and when formed into 29 groups of a few weeks each the largest group difference is $0^s.07$ and the average group difference $0^s.02$. The probable error of a determination of a clock correction on either instrument is $\pm 0^s.011$. These instruments are thus found to hold together for the five years, and the comparison shows the discontinuities at reversal which must be taken account of in absolute time or longitude work, but which may not be known in provisional work within $0^s.1$. Incidentally it was found that the introduction of a new relay system in the standard clock circuit in 1915 changed the relative clock corrections on these two instruments by $0^s.05$.

The next comparison given is that from four instruments. During the Paris-Washington longitude determination Oct. 1913–Apr. 1914, the 9-inch transit, the 6-inch transit, and two 3-inch Prin transits were being used simultaneously at the Naval Observatory. The 9-inch and 6-inch instruments are permanently mounted in identical large buildings, the instruments being from 15 to 30 feet from the 3-foot meridian openings. The 3-inch transits were mounted in small houses with low roofs the two halves of which move off leaving the instruments largely in the open air.

These latter instruments have motor driven traveling wires, and were reversed in the middle of each observation, and with them observations of zenith stars were taken. The azimuths of all instruments were controlled by readings on meridian marks. The clock corrections determined on the same nights were reduced to the same times by means of adopted clock rates, differenced by pairs of instruments, and the mean differences for each half of the work taken off. It was then found that the largest difference was $0^{s}.08$ for the two 3-inch transits, one used by the French and one used by the Americans, with an average on 53 nights of $0^{s}.03$; the largest difference was $0^{s}.07$ for the 9-inch and 6-inch instruments, with an average on 41 nights of $0^{s}.02$; the largest difference was $0^{s}.06$ for the 6-inch and 3-inch American instruments, with an average on 61 nights of $0^{s}.02$. An extra make-circuit relay was used with the chronographs of the longitude instruments, and the storage battery operating this circuit was found in a very run down condition at the end of the work. It is considered that some of the small progressive change of these instruments relatively to the large ones was due to this relay system. It appears that an individual clock correction on any of these instruments standing out $0^{s}.1$ from the mean is rare; that the average residual is less than $0^{s}.03$; and that there is little choice of instruments or houses. It also appears that sustained fluctuations of $0^{s}.1$ in the clock corrections can hardly be attributed to observations reduced in a definitive way as these have been.

By a comparison of the times that the wireless time signals sent from Washington, Paris, and Berlin were received at Greenwich, Uccle and Edinburgh, PROF. SAMPSON (*M. N.*, Jan. 1922) has recently shown the variation in the time determined at each observatory as compared with the mean of all, for a period of 21 months in 1920-1921. These variations amount to $0^{s}.3$ or $0^{s}.1$. At the receiving stations clock corrections were interpolated, at the sending stations extrapolated, and in all cases the comparisons depend upon provisional determinations of time the errors of which have just been indicated. As one is not dealing here with the more definitive work as carried on in longitude determinations, PROF. SAMPSON's conclusion as to the bearing of this comparison on longitude results should, therefore, be considerably modified. The Washington signals were examined as follows. The definitive clock corrections from observations on the 9-inch transit were formed into normals of a few days period, and plotted, and a smooth curve drawn through them. From this curve the corrections to the standard clock were read off for each day in the 21 months covered by the comparison, and from them the corrections to the time signals as recorded on the chronograph by the transmitting clock were deduced. The Washington signals as sent through Annapolis were received at Greenwich, and an element of uncertainty arose in the comparison as it was not known how many signals were received each week, or whether an occasional wild signal was used. During this period the clock corrections upon which the Washington signals were based were determined from observations of stars near the zenith with the 6-inch transit circle. This instrument was reversed three times, and by a comparison of the clock corrections from simultaneous observations on this instrument and on the 9-inch transit circle, as explained before, the discontinuities in the clock corrections at the reversals of the 6-inch were found to be: $+0^{s}.11$, Nov. 5, 1920; $-0^{s}.16$, Mar. 2, 1921; and $+0^{s}.08$, May 26, 1921; and the corresponding corrections to the signals are; $+0^{s}.06$ before Nov. 6; $-0^{s}.08$, Nov. 6 to Mar. 1; $+0^{s}.08$ Mar. 2 to May 25; and $0^{s}.00$ from May 26. With the application of these corrections the systematic variations in the Washington signals largely disappear. The accidental variations were also considerably reduced by applying the corrections for interpolated clock corrections, and using these two corrections the average of the weekly differences for Washington as given by PROF. SAMPSON was reduced from $\pm 0^{s}.060$ to $\pm 0^{s}.038$. Using corrections from the 9-inch curve this average would have been $\pm 0^{s}.043$. The difference between the two instruments was $\pm 0^{s}.028$. As the two instruments upheld each other further corrections were not investigated. The observers, instruments, chronographs, instrumental constants, methods of observing and reducing, and star places were all different and independent. It is possible that some local condition affects results from both instruments similarly. As variations of similar size appear for all observatories it is considered that with corrections which may be found from examinations elsewhere the differences in the times for each observatory from a new mean of all will be quite different from, and materially smaller than, those first derived. Several of the observatories find outstanding residuals due to weak determinations of azimuth. Positions in the *National Ephemerides* are so far wrong for at least two of the circumpolar stars that azimuths determined from them are in error by $0^{s}.1$, and these stars might be used for a number of weeks at a time in azimuth work. Errors of transmission and reception of signals are liable. From these investigations it is found that the variations in the times determined at large observatories are more or less due to the provisional nature

of the astronomical observations and reductions used; that by properly planning the provisional work the variations in the preliminary times may be partly eliminated and partly corrected for by later definitive reductions; and that longitude determinations need not be subject to such uncertainties.

In conclusion it is suggested that for the determination of time to be sent out daily for commercial or other uses, observations of zenith stars be taken on the smaller and quickly reversible transits, and that a study of the behavior of such instruments over long periods be made by comparisons with standard observatory instruments.

It has also been suggested that fixed observatories equipped with standard instruments under constant study receive a few, and the same, signals, month after month, year after year, under all conditions of temperature, and at all seasons. The data so accumulated would doubtless prove of great value in the determination of longitudes, and for the determination of variations of longitude coördinate with the variations of latitude.

PROPER-MOTION OF *B.D.* +14° 2374,

By R. H. TUCKER.

The star *B. D.* +14° 2374, magnitude 7.0, has recently been observed here with the meridian circle. The position for 1923.0 is given below, with those of several earlier catalogues, from which the approximate values of the proper-motion have been derived.

Proper-motion, $\mu\alpha = -0^s.0135 \quad \pm 0^s.0010$,
$\mu\delta = +0''.022 \quad \pm 0''.002$.

Lick Observatory,
May 24, 1923.

Cat.	Epoch	R. A. 1923.0	Decl.
W. B.	1825	11h 15m 7s.52	+13° 48′ 41″.2
Bonn VI	56.3	6 .83	42 .8
Leip. A. G.	69.8	6 .66	42 .8
Gl. I	70.2	6 .76	. .
	74.3		42 .34
Gl. II	88.7	6 .71	.
	86.9		42 .66
Lick	1923.37	6 .068	43 .67

PHOTOGRAPHIC DETERMINATION OF THE POSITIONS OF STARS IN THE FIELD OF THE LUNAR ECLIPSE OF 1924, AUG. 14,

By T. P. BHASKARAN

At the request of Mr. L. J. Comrie, who intends to publish predictions in the *British Astronomical Association's Handbook for 1924*, the places of stars situated in the region of the lunar eclipse of 1924, Aug. 14, were determined at this observatory. Four photographs of the field were taken with the Astrographic Equatorial and were measured and reduced in the same manner as those for the '*Carte du ciel*'. The details of the plates are as follows

TABLE I

Date 1922	Plate No.	Centre R. A. 1900.0	Centre Decl. 1900.0	Hour Angle	Exposures
Nov. 14	2025	21h32m	−14° 0′	1h35m W	12½m, 6m & 1m
Nov. 15	2027	21 32	−14 40	1 13 W	12 , 6 & 1
Nov. 15	2028	21 38	−13 50	1 34 W	10 , 6 & 1
Nov. 14	2026	21 38	−14 30	2 4 W	15 , 6 & 1

Only stars showing the 1 minute image quite distinctly were measured on these plates. Each was measured independently by two observers, both in the direct and reverse positions under the microscope.

The reductions were performed by the well known Turner method adopted for the '*Carte du ciel*' plates; the positions of the reference stars (about 25 in number on each plate) were obtained from the A.G. Catalogues, Cambridge, U. S. A. and Washington. The residuals Hyd. — A. G. C. were generally small; the mean differences irrespective of sign were

Δx	Δy
$0^s.058$	$0''.59$

excluding six stars which have rather large residuals; of these the star B.D. − 14° 6102 = 42 *Capricorni* appears in all the four plates. The P. M. derived from the residuals is 27″ per century in angle 202°, which agrees fairly well with those given by Boss and Porter.

The following table gives the positions of 67 stars in the region brighter than 9.5 magnitude in the *B. D.* scale.

TABLE II

No.	B.D. Number	Mag.	R. A. (1900)	Dec. (1900)	No. of Plates
			h m s	° ′ ″	
1	14 6064	9.4	21 28 15.32	14 31 3.0	2
2	14 6065	9.3	21 28 17.74	14 10 40.8	2
3	14 6071	9.3	21 28 58.93	14 5 21.1	1
4	14 6072	8.8	21 29 15.98	14 21 0.0	2
5	14 6073	9.3	21 29 16.77	14 28 18.2	2
6	14 6074	9.3	21 29 36.85	14 29 39.6	1
7	14 6075	9.5	21 30 15.18	14 30 29.8	2
8	14 6076	9.1	21 30 36.78	14 8 24.9	2
9	14 6077	9.0	21 30 42.98	14 18 54.5	2
10	14 6078	8.7	21 30 56.98	14 25 32.2	2
11	14 6081	9.0	21 31 35.78	14 47 34.9	2
12	14 6082	9.0	21 31 36.44	14 25 34.7	2
13	13 5976	9.4	21 32 1.34	13 45 36.2	1
14	13 5977	9.4	21 32 10.93	13 21 33.4	1
15	14 6085	9.5	21 32 17.34	14 45 17.2	2
16	13 5979	9.5	21 32 23.56	13 42 49.0	1
17	15 6025	9.3	21 32 28.20	15 25 34.3	1
18	14 6086	9.2	21 32 30.59	13 54 11.4	2
19	13 5980	9.0	21 32 10.28	13 40 1.4	2
20	15 6027	7.2	21 32 45.09	15 21 37.6	1
21	14 6087	9.5	21 32 47.48	14 39 34.3	2
22	14 6088	8.0	21 32 48.64	13 58 59.2	2
23	14 6089	9.3	21 33 5.59	13 53 7.7	2
24	14 6090	9.2	21 33 8.98	14 0 16.3	2
25	14 6093	9.4	21 33 39.70	14 14 37.0	2
26	13 5982	9.2	21 33 44.91	12 48 9.5	1
27	14 6094	7.0	21 33 47.91	14 20 40.9	1
28	14 6095	8.2	21 33 47.78	14 30 34.9	1
29	13 5983	9.2	21 33 52.45	13 32 32.2	2
30	13 5984	9.5	21 34 4.89	13 3 50.4	1
31	13 5985	8.3	21 34 13.49	13 4 28.4	2
32	14 6096	9.1	21 34 23.40	14 3 49.4	1
33	15 6030	9.4	21 34 37.28	15 26 44.4	2
34	13 5988	9.4	21 34 59.87	12 59 40.3	1
35	15 6033	8.5	21 35 8.46	14 50 2.2	1
36	15 6034	9.4	21 35 16.69	15 9 7.3	2
37	−14 6099	9.4	21 35 23.30	14 3 27.6	1
38	−14 6100	9.4	21 35 44.05	14 28 44.0	1
39	−15 6035	9.4	21 35 45.46	15 26 34.4	2
40	13 5990	9.3	21 35 50.01	12 50 40.4	1
41	−14 6101	8.9	21 35 53.46	14 23 21.6	1
42	−15 6037	7.2	21 35 59.81	15 47 46.0	2
43	−14 6102	5.5	21 36 6.47	14 29 43.0	1
44	−13 5991	9.3	21 36 14.49	13 26 28.8	1
45	−14 6103	8.7	21 36 17.30	14 38 53.7	1
46	−13 5992	9.4	21 36 17.40	13 42 6.6	2
47	−13 5993	9.2	21 36 32.07	12 50 22.7	1
48	−15 6040	9.0	21 36 38.56	15 4 33.2	2
49	−14 6104	9.4	21 36 38.64	14 18 36.8	2
50	−15 6041	9.4	21 36 48.09	15 5 4.4	1
51	−15 6042	9.0	21 37 7.40	15 43 57.0	1
52	−13 5999	9.4	21 37 14.44	13 25 44.4	1
53	−14 6107	9.3	21 37 14.28	14 25 58.4	2
54	−14 6110	9.4	21 37 32.59	14 7 41.2	2
55	−15 6045	9.3	21 37 35.52	15 49 3.0	1
56	−15 6046	6.2	21 37 37.07	14 51 24.4	2
57	−15 6047	9.4*	21 37 37.83	15 1 13.7	1
58	−13 6002	9.5	21 37 52.36	13 43 33.4	2
59	−15 6048	9.4	21 37 56.95	15 35 57.9	1
60	−14 6111	9.4	21 37 57.85	14 37 33.7	2
61	−14 6113	8.9	21 38 34.60	14 21 28.9	2
62	−14 6114	8.9	21 39 19.42	14 25 10.0	2
63	−14 6115	9.5	21 39 49.54	14 22 20.2	2
64	−14 6116	8.7	21 39 52.36	14 8 9.4	2
65	−14 6119	8.7	21 40 2.54	14 6 5.7	2
66	−14 6121	9.3	21 41 21.38	13 58 25.0	2
67	−14 6125	9.0	21 44 46.92	13 57 55.2	2

Columns 2 and 3 give the *B. D.* number and *B. D.* magnitude.

Columns 4 and 5 give the R. A. and Decl. for the epoch 1900.0 computed from the rectangular coordinates. The conversion to equatorial coordinates was performed by means of the formulae and tables given by Hnatek in A. N. 4329.

Column 6 shows the number of plates from which the positions have been derived.

The positions of stars fainter than 9.5 mag. are not given as there is doubt whether much weight can be attached to observations of occultations of stars fainter than this magnitude.

Nizamiah Observatory, Hyderabad (Deccan), India, 1923, March.

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OBSERVATIONS OF COMETS AND MINOR PLANETS,

MADE WITH THE 433 MM. REFRACTOR OF LA PLATA OBSERVATORY,

By BERNHARD H. DAWSON

Date, G. M. T.	★	Comp.	cos δ · Δα	Δα	Δδ	α 1921.0	δ 1921.0	log p · Δ in α	log p · Δ in δ
			(965) *Angelica*						
1921				s	′ ″	h m s	° ′ ″		
Nov. 7.52203	1	8,8	242.″0	+ 16.49	+3 35.4	0 29 17.40	−12 11 25.3	8.965*n*	0.531*n*
8.56544	2	10,10	179. 6	+ 12.24	−3 54.6	29 8.65	12 3 38.9	8.713	0.531*n*
18.52959	3	10,10	277. 2	− 20.16	+5 0.0	0 21 23.58	−10 39 47.2	8.540	0.555*n*
			Comet 1922 *a* (Reid)						
1922							1922.0		
Feb. 1.61936	4	10,10	184. 8	+ 15.16	−4 58.9	9 46 15.26	−35 40 48.7	9.472*n*	9.622*n*
3.55155	5	10,10	67. 2	− 5.54	−2 13.5	44 11.84	−36 1 2.2	9.671*n*	0.157*n*
4.62220	6	10,10	253. 7	+ 20.97	+3 35.8	43 2.92	11 10.0	9.405*n*	9.262*n*
5.59607	7	10,10	228. 5	+ 18.92	+4 56.2	42 0.12	19 44.2	9.547*n*	9.664*n*
6.59080	8	10,10	55. 6	− 1.61	−2 35.8	40 55.98	27 53.0	9.526*n*	9.672*n*
9.70312	9	10,10	78. 8	+ 6.56	−0 55.3	37 35.64	49 10.6	9.031	9.401
10.72940	10	10,10	2. ″44	+ 0.44	+2 5.4	36 29.69	−36 51 51.9	9.335	8.67
12.55244	11	10,10	178.″9	+ 14.94	+4 2.5	34 35.12	−37 3 22.5	9.594*n*	9.837*n*
13.50768	12	10,10	213. 7	− 17.86	−0 51.9	33 35.71	7 3.7	9.696*n*	0.180*n*
13.52338	13	10,10	169. 8	+ 14.19	−0 38.9	33 34.89	7 7.9	9.663*n*	0.068*n*
14.58084	14	10,10	108. 1	− 9.04	−0 24.6	32 29.46	10 32.5	9.448*n*	9.091*n*
15.65524	15	10,10	167. 3	+ 14.00	−5 44.3	31 21.47	13 22.8	7.679	9.583
20.65737	16	10,10	231. 8	+ 19.42	−5 35.7	26 31.88	18 6.9	8.889	9.555
20.69282	17	10,10	75. 3	+ 6.32	+2 46.0	26 32.80	18 4.9	9.320	9.403
23.52636	18	10,10	109. 3	+ 9.16	+3 31.9	24 2.93	15 0.0	9.555*n*	9.666*n*
26.56300	19	10,10	129. 9	− 10.86	−3 35.9	21 34.57	7 30.2	9.306*n*	9.067
27.58717	20	10,10	108. 2	+ 9.04	+1 8.5	20 48.22	4 6.1	9.005*n*	9.471
27.60741	21	10,10	303. 1	+ 25.32	−4 31.8	20 47.20	−37 4 1.8	8.390*n*	9.551
Mar. 1.66662	22	10,10	356.°36	− 0.96	+3 0.3	19 18.95	−36 55 52.9	9.342	8.595
1.68310	23	10,10	186. 21	− 0.61	−1 6.7	19 18.19	55 50.0	9.442	9.166*n*
1.69952	24	10,10	49.″7	− 4.14	−0 57.7	19 17.42	55 45.5	9.519	9.572*n*
2.64768	25	10,10	137. 3	+ 11.41	−0 49.8	18 39.61	51 26.9	9.212	9.219
2.66721	26	10,10	31. 5	− 2.63	−1 2.8	18 38.73	51 21.9	9.367	8.016*n*
2.68206	27	10,10	355.°32	− 0.94	+2 18.0	9 18 38.12	51 15.8	9.453	9.267*n*
3.60461	28	10,10	2. 30	+ 0.50	+2 30.6	9 18 3.00	−36 46 16.0	8.429	9.497

Date. G. M. T.	★	Comp.	cos δ · Δα	Δα	Δδ	α 1922.0	δ 1922.0	log p · Δ in α	log p · Δ in δ
				Comet 1922 *a* (REID) (*Continued*)					
1922				s	′ ″	h m s	° ′ ″		
Mar. 3.62625	29	10,10	118.″5	− 12.35	−2 58.3	18 2.06	−36 16 11.1	8.978	9.116
5.67257	30	10,10	175. 5	− 14.58	+1 46.8	16 19.15	35 36.7	9.151	9.344*n*
5.68589	31	10,10	75. 0	− 6.23	−0 55.0	16 18.11	35 32.3	9.513	9.607*n*
5.70219	32	10,10	190.″07	− 0.58	−0 39.1	16 48.14	35 27.1	9.575	9.836*n*
6.59819	33	10,10	42.″8	− 3.56	+1 43.3	16 49.12	30 40.3	8.392	9.130
6.61138	34	10,10	102. 8	+ 8.52	−0 35.3	16 18.84	30 6.2	8.871	9.379
7.61830	35	10,10	21. 6	− 1.79	−2 25.8	15 47.52	23 54.6	9.047	9.259
7.64051	36	10,10	160. 1	+ 13.29	+1 47.3	15 46.87	23 45.1	9.284	8.456
8.74448	37	10,10	53. 9	− 1.46	+0 16.7	15 14.88	16 35.1	9.697	0.222*n*
8.77150	38	10,10	65. 8	+ 5.44	−0 21.4	15 13.82	−36 16 23.9	9.744	0.390*n*
15.18244	39	10,10	179. 5	− 14.69	−0 59.3	12 52.54	−35 26 39.4	9.467*n*	9.644*n*
15.19867	41	10,10	322. 6	+ 26.39	−4 14.3	12 52.33	26 32.1	9.378*n*	9.393*n*
17.50013	42	10,10	21. 2	+ 1.97	+3 37.0	12 26.79	9 58.2	9.327*n*	9.327*n*
17.51345	43	10,10	88. 3	− 7.20	−2 21.9	12 26.76	−35 9 52.4	9.222*n*	9.041*n*
19.55700	44	10,10	65. 0	+ 5.29	+1 48.3	12 8.60	−34 52 18.3	8.439	8.324
20.49785	45	10,10	179.″96	+ 0.01	−2 4.1	12 3.09	44 3.3	9.294*n*	9.371*n*
20.51559	46	10,10	193.″6	+ 15.70	−1 18.3	12 3.03	43 55.6	9.107*n*	8.992*n*
21.50161	47	10,10	231. 5	− 18.75	+3 53.8	11 58.83	35 7.3	9.224*n*	9.286*n*
21.51738	48	10,10	181. 1	+ 11.66	−3 10.9	11 58.73	35 0.9	9.046*n*	8.984*n*
22.59999	49	10,10	162. 2	+ 13.41	+3 25.9	11 56.30	25 46.1	9.298	9.462*n*
23.18470	50	10,10	100. 3	− 8.09	−0 31.5	11 55.99	17 15.9	9.315*n*	9.520*n*
23.49693	51	10,10	238. 7	− 19.26	+1 3.8	11 56.13	17 1.7	9.215*n*	9.366*n*
23.50936	52	10,10	259. 2	+ 20.94	−0 17.2	11 56.27	16 57.6	9.078*n*	9.490*n*
23.52034	53	10,10	243. 0	+ 19.61	+0 40.4	9 11 56.05	−34 16 51.4	8.903*n*	9.029*n*
				Comet 1922*d* (SKJELLERUP)					
						1932.0	1923.0		
Dec. 8.77369	54	10,10	434. 6	− 9.71	−2 32.9	12 8 45.89	−22 28 32.5	9.672*n*	0.535*n*
9.77241	55	10,10	328. 3	− 23.84	−1 52.9	14 8.83	−23 24 55.7	9.678*n*	0.534*n*
13.74586	56	10,10	45. 6	+ 3.40	+5 58.7	38 1.11	−26 13 45.9	9.720*n*	0.572*n*
13.78291	57	16,	.	+ 97.70	. . . .	38 44.13	. . . . .	9.684*n*	. . . . .
13.80656	58	8,8	50. 1	− 3.74	+1 2.9	38 23.26	−26 16 44.2	9.643*n*	0.416*n*
15.72857	60	10,10	271. 4	+ 20.77	−1 10.5	50 9.64	−28 16 7.5	9.736*n*	0.608*n*
15.77653	61	18,	.	+151.91	. . .	50 27.36	. . . . . .	9.702*n*	. . . . .
15.77665	62	17,	. .	+115.47	. . . .	12 50 27.37	. . . . . .	9.702*n*	. . . . .
17.73637	63	10,10	161. 8	− 12.43	+2 33.6	13 2 35.17	−29 44 19.4	9.740*n*	0.588*n*
18.72662	64	10,10	61. 0	+ 1.74	−7 2.6	13 8 45.22	−30 25 36.4	9.746*n*	0.612*n*
18.75598	65	10,10	278. 2	+ 21.52	+1 46.1	8 56.04	−30 26 45.2	9.734*n*	0.535*n*
21.73693	66	10,10	115. 6	+ 11.50	+3 51.5	27 35.60	+32 21 27.7	9.754*n*	0.587*n*
21.78158	67	10,10	85. 6	+ 6.76	+1 43.4	27 52.53	23 5.7	9.725*n*	0.449*n*
22.77926	69	10,10	173. 1	+ 13.78	+0 6.0	31 8.30	58 11.1	9.738*n*	0.479*n*
22.79183	70	10,10	9. 9	+ 0.78	−1 17.1	31 14.14	−32 58 43.9	9.714*n*	0.397*n*
23.77014	71	10,10	46. 9	+ 3.75	+1 53.0	40 22.08	−33 31 28.2	9.754*n*	0.485*n*
23.78177	72	10,10	12. 7	− 1.02	−0 58.2	13 40 26.34	−33 31 52.2	9.734*n*	0.444*n*
27.75271	73	10,10	352. 2	+ 28.82	−3 24.1	14 5 24.32	−35 28 50.4	9.768*n*	0.545*n*
27.77213	74	10,10	51. 1	+ 4.18	−1 4.5	5 28.52	−35 29 25.1	9.758*n*	0.480*n*
30.77970	75	10,10	142. 6	+ 11.84	+2 27.0	24 10.49	−36 41 6.9	9.762*n*	0.455*n*
30.79749	76	10,10	230. 6	− 19.18	+3 32.5	24 16.62	−36 41 30.8	9.746*n*	0.380*n*
30.84102	77	15,	348. 2	− 28.95		24 21.46	. . .	9.729*n*	. . . . .

Comet 1922*d* (Skjellerup) — (*Continued*)

Date, G. M. T.	★	Comp.	cos δ · Δα	Δα	Δδ	α 1923.0	δ 1923.0	log p · Δ in α	log p · Δ in δ
1923				s	′ ″	h m s	° ′ ″		
Jan. 2.78145	78	10,10	58. 0	+ 4.88	−5 16.1	14 42 33.10	−37 38 50.3	9.770*n*	0.455*n*
2.79746	79	10,10	329. 2	− 27.71	−2 38.7	42 38.87	39 6.9	9.756*n*	0.385*n*
3.73176	80	12,12	32. 1	+ 2.71	+2 10.5	48 18.16	−37 54 17.4	9.785*n*	0.628*n*
4.73510	81	12,12	133. 8	+ 11.34	+1 43.0	14 54 19.67	−38 9 16.9	9.786*n*	0.621*n*
5.75604	82	12,12	166. 0	− 14.11	−7 2.5	15 0 24.14	−38 23 10.3	9.787*n*	0.558*n*
10.75199	83	12,12	178.°55	+ 0.77	−6 14.4	29 18.01	−39 11 38.9	9.793*n*	0.587*n*
12.74557	84	12,12	112.″3	+ 9.69	+5 13.8	40 23.59	22 49.5	9.794*n*	0.613*n*
15.76043	86	12,10	324. 6	+ 28.06	−1 13.0	15 56 37.87	32 0.1	9.795*n*	0.575*n*
16.75330	88	10,10	159. 1	+ 13.76	+2 43.2	16 1 49.67	33 1.8	9.795*n*	0.601*n*
16.78656	89	10,10	43. 8	− 3.79	+1 38.9	2 0.06	33 6.7	9.788*n*	0.482*n*
16.80732	90	20,	……	+ 91.55		2 6.50		9.774*n*	
16.80732	91	20,	……	− 34.79		2 6.51		9.771*n*	
20.75438	92	12,12	96. 3	− 8.33	+6 20.5	22 0.17	29 7.3	9.795*n*	0.607*n*
23.80358	94	12,12	148. 9	+ 12.84	+4 57.1	36 31.96	18 8.4	9.779*n*	0.432*n*
24.78907	96	12,12	321. 6	− 27.68	+0 55.0	41 3.85	13 19.9	9.788*n*	0.496*n*
24.80696	97	10,10	115. 6	− 9.94	−5 59.6	16 41 9.00	−39 13 14.0	9.777*n*	0.420*n*
29.77694	98	12,12	302. 0	+ 25.79	+2 14.1	17 2 50.54	−38 40 38.6	9.789*n*	0.551*n*
Feb. 5.77674	99	10,10	163. 8	+ 13.79	−1 38.6	30 9.82	−37 36 50.1	9.783*n*	0.559*n*
5.79780	100	10,10	301. 6	− 25.39	+2 22.7	30 14.18	36 36.7	9.774*n*	0.483*n*
6.81280	101	10,10	217. 0	+ 18.21	−4 11.3	33 54.00	26 3.4	9.762*n*	0.423*n*
6.82818	102	10,10	200. 2	− 16.80	−6 36.2	33 57.12	25 53.1	9.746*n*	0.352*n*
7.80327	103	10,10	15. 8	+ 1.32	−1 15.0	37 23.80	15 28.2	9.768*n*	0.461*n*
7.81658	104	10,10	215. 9	− 18.08	−2 59.6	37 26.65	15 20.3	9.757*n*	0.408*n*
8.81680	105	10,10	162. 8	− 13.60	+0 0.6	40 54.26	−37 1 24.8	9.756*n*	0.408*n*
8.83042	106	10,10	173. 0	− 14.45	−2 21.1	40 56.90	−37 1 16.9	9.741*n*	0.345*n*
13.74120	107	10,10	13. 3	− 1.10	−1 42.7	56 57.12	−36 7 43.3	9.772*n*	0.660*n*
13.76140	108	10,10	58. 4	+ 4.82	+2 30.8	17 57 0.90	−36 7 26.4	9.775*n*	0.606*n*
16.77187	109	10,10	322. 0	+ 26.37	−1 22.8	18 6 2.43	−35 30 57.2	9.771*n*	0.572*n*
16.78983	110	10,10	89. 6	+ 7.34	+1 41.9	6 5.06	30 41.8	9.764*n*	0.514*n*
16.80955	111	10,10	112. 0	− 9.17	−0 17.4	6 8.59	−35 30 25.0	9.750*n*	0.442*n*
19.74366	112	10,10	58. 2	+ 4.74	+5 25.5	14 22.72	−34 53 52.0	9.767*n*	0.648*n*
19.75826	113	10,10	184. 3	+ 14.97	−7 23.6	14 25.33	53 44.2	9.769*n*	0.609*n*
19.77642	114	10,10	154. 0	− 12.52	+1 2.8	14 27.60	53 28.5	9.766*n*	0.558*n*
20.74989	115	10,10	147. 6	+ 11.97	+4 44.1	17 5.37	41 6.3	9.767*n*	0.630*n*
20.76742	116	10,10	255. 8	+ 20.71	−1 24.8	17 7.81	40 55.1	9.767*n*	0.582*n*
21.76855	117	10,10	86. 9	+ 7.03	+1 5.7	19 45.50	28 11.6	9.765*n*	0.577*n*
21.78295	118	10,10	81. 8	+ 6.61	−1 18.1	19 47.63	28 0.7	9.760*n*	0.533*n*
21.79571	119	10,10	115. 8	− 9.36	−1 8.8	19 49.55	27 49.7	9.752*n*	0.490*n*
23.78178	120	10,10	246. 9	+ 19.86	−3 20.4	24 52.24	2 23.5	9.757*n*	0.534*n*
23.79880	121	10,10	183.°40	− 0.34	−1 9.6	24 54.69	2 11.1	9.746*n*	0.477*n*
23.81946	122	10,10	42″.3	− 3.40	+2 49.6	24 57.64	−34 1 55.1	9.725*n*	0.399*n*
24.78892	123	10,10	356. 92	− 0.55	+2 8.9	27 20.04	−33 49 29.0	9.751*n*	0.509*n*
24.80114	124	10,10	35″.9	− 2.88	−2 34.5	18 27 21.97	−33 49 18.2	9.742*n*	0.467*n*

(132) *Aethra*

Date, G. M. T.	★	Comp.	cos δ · Δα	Δα	Δδ	α 1923.0	δ 1923.0	log p · Δ in α	log p · Δ in δ
1923									
Feb. 24.5333		Photogr.	……	……	……	5 22 27.85	+ 0 11 43.1	9.344	0.702*n*
Mar. 2.48426	125	10,10	146. 1	− 9.74	−2 2.9	28 16.40	− 0 12 37.3	9.064	0.697*n*

Date G. M. T.		★	Comp.	cos δ · Δα	Δα	Δδ	α 1923.0	δ 1923.0	log p · Δ in α	log p · Δ in δ
				(132) *Aethra* — (*Continued*)						
1923					s	′ ″	h m s	° ′ ″		
Mar.	3.50306	126	10,10	32. 6	− 2.18	+1 32.8	29 57.91	− 0 16 17.9	9.245	9.697*n*
	4.49165	127	10,10	57. 9	− 3.86	−0 31.1	31 9.24	19 45.2	9.172	0.696*n*
	7.50941		Photogr.				34 57.72	29 40.4	9.331	0.695*n*
	8.50186	128	10,10	87. 2	− 5.81	+1 50.3	36 16.37	32 40.9	9.298	0.694*n*
	10.55496	129	10,10	231. 1	− 15.41	+0 11.6	39 1.19	38 12.7	9.530	0.695*n*
	13.49331	130	20,10		+ 16.98	+0 11.6	43 17.90	46 15.6	9.299	0.692*n*
	14.50963	131	10,10	273. 6	+ 18.24	−2 20.4	5 41 48.66	− 0 49 26.4	9.393	0.692*n*
				(147) *Valentine*						
1923										
Apr.	18.69037	132	14,14	276. 6	+ 19.12	+3 28.1	15 21 38.72	−15 22 40.0	9.092*n*	0.473*n*
	24.70345	133	14,14	69. 1	− 4.79	−3 39.4	20 28.77	11 9.4	8.360*n*	0.469*n*
	25.61394	136	12,12	15. 7	+ 1.09	−4 59.2	19 48.15	9 19.7	9.443*n*	0.514*n*
	26.65802	(A)	14,9		+ 11.75	−0 9.9	19 4.19	7 8.6	9.156*n*	0.481*n*
	27.61756	138	12,12	240. 1	+ 16.58	+2 25.2	15 18 16.20	−15 5 5.2	9.217*n*	0.486*n*

Mean Places of the Comparison Stars

★	α 1921.0	δ 1921.0	Authority
	h m s	° ′ ″	
1	0 29 30.93	−12 15 0.7	Plates 59, 61, 62, 63, 64.
2	28 56.11	−11 59 44.3	Plates 61, 62, 63, 64.
3	0 24 43.71	−10 44 47.2	*A. G. Chr. M.*, 86.
	1922.0	1922.0	
4	9 46 0.10	−35 35 49.8	−35°127, 142; −36°504.
5	44 17.35	−35 58 48.7	−35 35; −36 376.
6	42 14.95	−36 14 45.8	−36 282; −37 655.
7	44 41.20	24 40.4	−36 206, 227; −37 614.
8	41 0.59	25 17.2	−36 205, 226; −37 689, 610.
9	37 29.08	18 15.3	*Perth Mer.* 5, 816.
10	36 29.25	−36 56 57.0	−36 53; −37 450.
11	34 20.48	−37 4 25.0	−36 26; −37 405.
12	33 53.60	6 41.8	−36 6; −37 376.
13	33 20.70	6 29.0	−36 4; −37 374.
14	32 38.50	10 10.9	−36 30; −37 372.
15	31 10.17	8 11.5	−37 436; Plate 118.
16	26 15.46	12 31.2	−37 385; Plate 118.
17	26 26.48	20 20.9	−37 345; Plate 118.
18	23 53.77	18 31.9	Plate 118.
19	21 45.43	3 54.3	−36°60; −37°412; Plate 118.
20	20 39.18	5 41.6	−36 57, −37 429, 439.
21	20 21.88	−37 2 30.0	−36 51; −37 471.
22	19 19.94	36 58 53.2	−36 80.
23	19 18.80	51 43.3	−36 116; −37°533.
24	19 21.56	54 47.8	−38 117; −37 534.
25	18 28.17	50 37.4	*Perth Mer.* 5, 788.

★	α 1923.0	δ 1923.0	Authority
	h m s	° ′ ″	
26	9 18 41.36	−36 50 19.1	−36°156; −37°558.
27	18 39.06	53 33.8	−36 113; −37 530.
28	18 2.50	49 16.6	−36 153; −37 556.
29	18 14.41	43 43.1	−36 196.
30	17 3.73	37 23.5	−36 236; −37 628.
31	16 54.77	31 37.3	−36 280; −37 668.
32	16 48.72	34 48.0	−36 278; −37 666.
33	16 22.68	31 53.6	−36 276; −37 664.
34	16 10.32	29 30.9	*Perth Mer.* 5, 784.
35	9 15 49.31	21 28.8	−36°376; 37 736.
36	9 15 33.58	25 32.7	−36 331.
37	15 19.34	17 21.8	−36 119; −37°765.
38	15 8.38	−36 16 2.5	−36 302, 416; −37°762.
39	13 7.23	−35 25 40.1	*40 −303″.8 +37″.6.
40	13 32.09	26 17.7	*Perth Mer.* 5, 781.
41	12 25.94	22 17.8	−35 276; −36°559.
42	12 24.82	13 35.2	−35 340; −36 602.
43	12 33.96	−35 7 30.5	−34 11; −35 365; −36°620.
44	12 3.31	−34 57 6.6	−34 11; −35 439.
45	12 3.08	11 59.2	−34 89; −35 513.
46	11 47.33	39 37.3	−34 110; −35 540.
47	12 17.58	39 1.1	−34 111; −35 541.
48	11 44.07	31 50.0	−34 132; −35 577.
49	11 43.19	28 42.0	−34 146; −35 610.
50	12 4.08	16 14.1	−34 173; −35 651.
51	12 15.39	18 8.5	−34 174; −35 653.
52	11 35.36	16 10.4	−34 171; −35 671.
53	9 11 36.41	−34 17 31.8	−34 172; −35 650.
	1923.0	1923.0	
54	12 8 25.60	−22 25 59.6	*Cord. A.* 9235.
55	14 32.67	−23 17 2.8	*Cord. A.* 9303.
56	37 57.71	−26 49 14.6	*57 +80s.98 +114″.5.
57	36 36.73	51 9.1	*Cord. A.* 9513.
58	38 27.00	50 14.1	*59 −10s.85 +402.9.
59	39 7.85	−26 56 57.0	*Cord. A.* 9538.
60	49 48.87	−28 14 57.0	*61 +113s.45; *62 +76s.95 +114″.4.
61	47 55.45	18 38.0	*Cord. B.* 8236.
62	12 48 34.90	−28 17 21.4	*Cord. B.* 8241.
63	13 2 47.60	−29 46 53.0	*Cord. B.* 8358.
64	8 40.51	−30 18 22.2	See note.
65	8 34.52	−30 31 31.3	*Cord. B.* 8408.
66	27 24.10	−32 25 19.2	−32 105, 109; −33°273.
67	27 45.77	27 49.1	*68 −138″.8 +372″.6.
68	27 56.49	34 1.7	*Perth Mer.* 1, 1134.
69	33 54.52	58 17.1	−32°28; −33°213.
70	13 34 13.36	−32 56 56.5	−32 29; −33 228.
71	13 40 18.33	−33 33 21.2	−33 102, 85; −34 307.
72	13 40 27.36	−33 30 54.0	−33 116; −34 323.
73	14 1 52.50	−35 25 25.7	*Perth Mer.* 5, 1201.
74	5 24.34	−35 28 23.9	−35°139; −36°421.

★	α 1923.0	δ 1923.0	Authority
	h m s	° ′ ″	
75	11 23 58.35	−36 43 33.9	−36 89; −37 279.
76	24 35.80	45 3.3	−36 90; −37 280.
77	24 50.41	−36 11 43.3	*Perth Mer.* 5, 1229.
78	42 28.22	−37 33 31.2	−37 128.
79	43 6.58	36 28.2	−37 107.
80	48 15.45	−37 56 27.9	Cape 1880, 8095.
81	11 51 8.33	−38 10 59.9	*Perth Mer.* 6, 1258.
82	15 0 38.25	−38 16 7.8	*Perth Mer.* 1265.
83	29 17.24	−39 5 21.5	*Perth Mer.* 6, 1304; 2, 1016.
84	40 43.90	28 3.3	*85, 2 .49, Δδ = +229″.4.
85	40 43.02	31 52.7	*Perth Mer.* 2, 1057.
86	56 9.81	30 47.1	*87 +217″.3 − 99″.3.
87	15 55 51.01	29 7.8	*Perth Mer.* 2, 1075.
88	16 1 35.94	35 45.0	*90 +60 .96 +135″.0.
89	2 3.85	34 45.6	*91 −37ˢ.45 +256″.7.
90	0 34.95	37 59.9	*Perth Mer.* 2, 1080.
91	2 44.30	39 2.3	*Perth Mer.* 2, 1084.
92	22 8.50	35 27.8	*93 +100″.7 +208″.2.
93	21 59.78	38 56.0	*Perth Mer.* 2, 1109.
94	36 19.12	23 5.5	*95 −72″.2 +236″.6.
95	36 25.35	27 2.1	*Perth Mer.* 2, 1128.
96	41 31.53	14 14.9	*Perth Mer.* 2, 1134.
97	16 41 18.91	−39 7 14.4	*Arg. G. C.*, 22651.
98	17 2 21.75	−38 42 52.7	*Perth Mer.* 6, 1431.
99	29 56.03	−37 35 11.5	−37°269.
100	30 39.57	38 59.1	−37 221.
101	33 35.79	21 52.1	−37 298.
102	34 13.92	19 16.9	−37 331.
103	37 22.18	14 13.2	−37 379.
104	37 44.73	12 20.7	−37 380.
105	41 7.86	1 25.4	−36 2; −37°481.
106	41 11.35	−37 1 55.8	−36 3; −37 482, 605.
107	56 58.22	−36 6 0.6	−36 738, 741; −37 1869.
108	17 56 56.08	−36 9 57.2	−36 736, 653; −37 1868.
109	18 5 36.06	−35 29 31.4	−35 674; −36°1472, 1455.
110	5 57.72	32 23.7	−35 558; −36 1395, 1362.
111	6 17.76	−35 30 7.6	−35 562; −36 1398, 1365.
112	14 17.98	−34 59 17.5	−34 42, 1; −35 962; −36°1872.
113	14 10.36	16 20.6	−34 110; −35 1222.
114	14 40.12	54 31.3	−34 44, 30; −35 1061.
115	16 53.40	45 50.4	−34 98; −35 1239.
116	16 17.07	39 30.6	−34 127; −35 1319.
117	19 38.17	29 17.3	−34 231; −35 1532, 1180.
118	19 41.02	26 12.6	−34 288; −35 1625, 1251.
119	19 58.91	−34 26 10.9	−34 291; −35 1255.
120	21 32.38	−33 59 3.1	*Perth Mer.* 3, 1423.
121	24 55.03	−34 1 1.5	−33 18; −34 173; −35 1563.
122	25 1.01	−34 4 11.7	34 433; −35 1519.
123	27 20.59	−33 51 37.9	−33 81, 62; −34 573.
124	18 27 21.85	−33 46 43.7	−33 109; −34 608.

★	α 1922.0	δ 1922.0	Authority
	h m s	° ′ ″	
125	5 28 56.14	− 0 10 34.4	Plate 172.
126	30 0.09	17 50.7	Plate 172.
127	31 13.10	19 11.1	*A. G. Nicol.* 1395.
128	36 22.18	34 31.2	Plate 173.
129	39 19.90	38 57.3	Plate 173.
130	42 30.92	47 30.2	*A. G. Nicol.* 1466.
131	5 44 30.42	− 0 47 6.0	*A. G. Nicol.* 1471.
132	15 24 19.61	−15 26 8.4	*A. G. Wash.* 5677.
133	20 33.56	7 30.3	(A) $+133^s.82$ $-31''.6$.
(A)	18 19.74	6 58.7	$\frac{1}{4}$ (*134 + *135 + *136 + *137)
134	15 33.55	4 19.9	*A. G. Wash.* 5627.
135	16 39.28	5 45.4	*A. G. Wash.* 5634.
136	19 47.36	7 20.5	*A. G. Wash.* 5651.
137	21 18.78	10 28.9	*A. G. Wash.* 5660.
138	15 17 59.62	−15 7 30.4	(A) $-20^s.12$ $-31''.7$.

NOTES

In those cases in which the column $\cos\delta\,\Delta\alpha$ is blank, the observations were made by the method of transits; when an angle is given, this position angle and $\Delta\delta$ were measured; in the remaining cases the observatins were by direct micrometer measurement of $\Delta\alpha$ and $\Delta\delta$. All values of $\Delta\alpha$ and $\Delta\delta$ have been corrected for differential refraction, and those relating to minor planets have also been corrected differentially for the effects of precession, nutation and aberration.

(965) *Angelica* was estimated as of visual magnitude 14.2.

Plates 59 to 61 were measured and reduced by Dr. J. Hartmann, using stars from *A. G. Cambridge M.*

Positions from the *Perth Astrographic Catalogue* are referred to by the declination of the zone and the number of the star in the plate. The right ascension of the plate centre is not given, as it can readily be found from that of the star.

*64 shows a not yet well-determined proper motion of over 0″.2 annually. It has been placed on the observing list for the *La Plata Meridan Circle*, but no observations are yet at hand. The place given is consequently only approximate.

Plate 148 has two equal exposures, and was reduced with 9 stars from the *Perth Meridian Catalogues*.

Plate 172 (Feb. 21) and Plate 173 (Mar. 7) were each reduced with 11 stars from *A. G. Nicolajew*. The measured positions of the images of (132) *Æthra* are included with the visual observations.

La Plata,
1923, May 17.

ORBIT OF COMET 1922*d* (SKJELLERUP),

By BERNHARD H. DAWSON.

From the La Plata observations of Comet 1922*d*, three groups were selected around the dates, December 14, January 23 and February 22, and normal places formed by means of the empirical formula

$$\gamma = \gamma_0 + A\,(t_0 - t) + B\,(t_0 - t)^2,$$

solved for each coördinate and date. Elements I were then obtained by the method of variation of the geocentric distances, and represented the middle normal within 3″. But on comparison of the individual observations with an *ephemeris* computed from Elements I, it was seen that the representation was decidedly unsatisfactory both before and after the December normal, and was also not exact at the normal epochs, due doubtless to the errors introduced by the application of the empirical formula directly to the coördinates.

The residuals resulting from this comparison were grouped into five normals in each coördinate, as given in the Table, and the differential coefficients computed for the corresponding dates with Elements I and the

Elements I

T	1923 Jan. 3.728151
ω	264° 32′ 15″.15
Ω	264 58 16 .99
i	= 23 22 16 .60
e	= 0.994 9005
log q	= 9.965 7111

Residuals, O − C

Date	I	II
Dec. 8.0	−1ˢ.51 + 22″.1	−0ˢ.52 + 2″.5
Dec. 28.0	+0 .98 − 10 .2	−0 .10 − 1 .2
Jan. 17.0	+0 .11 − 6 .1	−0 .40 − 0 .7
Feb. 6.0	−0 .22 − 3 .6	−0 .15 − 0 .1
Feb. 22.0	−0 .12 − 1 .5	−0 .25 + 1 .1

formula given by BAUSCHINGER in §116 of his *Bahnbestimmung*. On solving for the corrections and applying them, Elements II resulted, and with them the representation of the normals given in the Table. While there is marked improvement, the residuals in right ascension are still unsatisfactory.

Since my approaching absence from La Plata will make it impossible for me to continue this investigation, I here present the results so far obtained:

Elements II

1923 Jan. 3.723191 G. M. T.
264° 30′ 28″.73 ω' = 212° 56′ 52″.69
261 57 28 .11 Ω' = 308 40 49 .57 Mean Equinox 1923.0
23 21 58 .78 i' = 30 12 8 .74
0.993 7347
9.965 4791

$$x = [9.963\ 6288]\ r \sin\ (42°\ 48'\ 36''.37 + v)$$
$$y = [9.977\ 3991]\ r \sin\ (304\ \ 10\ \ 17\ \ .51 + v)$$
$$z = [9.701\ 6168]\ r \sin\ (212\ \ 56\ \ 52\ \ .69 + v)$$

La Plata,
May 15, 1923.

THE ECLIPSE OF SEPTEMBER 10, 1923,

By ARTHUR NEWTON.

(Communicated by the Superintendent, U. S. Naval Observatory, CAPTAIN W. D. MACDOUGALL, U. S. N.)

From corrections to the position of the *Moon*, which are published in the latest annual report of the *Astronomer Royal*, and which are obtained from 28 observations of the *Moon* made at Greenwich from January to April of the present year, and from similar corrections which are obtained from 15 observations of the *Moon* made with the 9-inch transit circle at the U. S. Naval Observatory from January to May of the present year, it has been found that the *Moon's* ephemeris given on pages 26-133 of the *American Ephemeris* and *Nautical Almanac* requires a correction amounting to +7″.1 in mean longitude and −0″.9 in latitude.

In the eclipse data adopted in the *American Ephemeris*, a correction has already been applied, amounting to +7″.0 in mean logitude and −0″.5 in latitude.

The *American Ephemeris* eclipse data, therefore, in the light of the most recent available observations, require a further correction of +0″.1 to the *Moon's* mean longitude and −0″.4 to the *Moon's* latitude. On September 10, 1923, these values transform to +0ˢ.02 in right ascension and −0″.5 in declination.

Applying a correction of +0ˢ.10 to the *Sun's* right ascension (see the *Astronomical Journal*, No. 691); and the corresponding correction of −0″.6 to the *Sun's* declination, the following results are obtained:

The time of conjunction in right ascension will be
2ˢ.2 later than the A. E. predicted time;

the time of occurrence of total phase will be
3ˢ.0 later than the A. E. predicted time:

and the central line of eclipse together with the northern and southern limiting curves of the path of total phase will lie 0′.6 of latitude farther south than as predicted.

Nautical Almanac Office, Washington,
July 17, 1923.

CONTENTS

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ON THE RELATION BETWEEN ABSOLUTE MAGNITUDE AND SPECTRAL CLASS AS DERIVED FROM OBSERVATIONS OF DOUBLE STARS.

By KNUT LUNDMARK AND WILLEM J. LUYTEN.

Various investigators[1] have studied the relation between theories of stellar evolution and magnitudes and colors of double stars. Assuming the Russell theory of evolution to hold, they have shown that the facts derived from observations of double stars can be satisfactorily explained. In the present paper we shall reverse the problem and attempt to show that from observations of double stars alone, a relation between spectral class and absolute magnitude may be derived, corresponding to the giant and dwarf theory.

If two stars are physically connected, and do not have too large an angular separation in the sky, we infer that their distance from us is the same. Accordingly the difference Δm in their apparent magnitudes equals the difference ΔM in their absolute mangitudes. For many double stars we know the spectral classes S_1 and S_2 of both components. Assuming a relation between M and S of the form $dM = \phi(S)\, dS$ we then have:

$$\Delta m = \Delta M = \int_{S_1}^{S_2} \phi(S)\, dS$$

Our problem is to determine $\phi(S)$ from a number of observed quantities ΔM, S_1 and S_2. This involves the solution of a functional equation of Abel's type. Such a solution has been discussed at length by SCHWARZSCHILD in connection with the general photographic-photometric problem. (*Astr. Nach.*, *172*, 65, 1906.)

In the present case the practical difficulties involved would make the solution very laborious. A rigorous solution seems almost impossible due to the fact that we have only an arbitrary scale in which to express S. A suitable scale which would enable us to assume a simple form for $\phi(S)$, e.g. $\phi(S) = C$ can only be determined from an approximate preliminary solution of the functional equation.

For the present we have satisfied ourselves with such an approximate solution. This was obtained by putting:

$$\Delta M = \frac{dM}{dS}\Delta S \text{ or } (m_1 - m_2) = \frac{dM}{dS}(S_1 - S_2)$$

$$\text{giving } \frac{dM}{dS} \text{ at the point } S' = \frac{S_1 + S_2}{2}$$

As a scale for S one was adopted which gives $S = 0$ for spectral class $B0$, $S = 10$ for $A0$, $S = 50$ for Ma etc. From data collected at Harvard, Mt. Wilson, and Lick, we have compiled a list of about five hundred physically-associated pairs for which the spectra of both components are known. The difference in spectral class, $S_1 - S_2$, surpassed 5 units in the above scale for 260 of these. Accordingly 260 more or less reliable values of $\Delta M/\Delta S$ could be obtained. These were arranged in order of size and the frequency curve shown in Figure 1 obtained.

It is evident that this curve is composed of two frequency curves with maxima at about $-.03$ and $+.22$ respectively. That the first maximum which corresponds to the giant-branch of the Russell diagram is so much higher than the second is only due to statistical selection.

The values of $\Delta M/\Delta S$ for the 22 stars with $S' = \frac{S_1 + S_2}{2} < 10$ were all positive with the exception of the value for *β Orionis*, -2.13. From this we conclude that the giant and dwarf branches meet at about $A0$. The whole Russell diagram was then constructed in the following way on this assumption.

The frequency curve as represented in Figure 1 was decomposed into two smooth curves, the left hand one for the giants, the right hand one for the dwarfs. The mean value of $\Delta M/\Delta S$ as obtained from the giant

[1]HERSCHEL, LAU, LEONARD, DOIG, *et al*

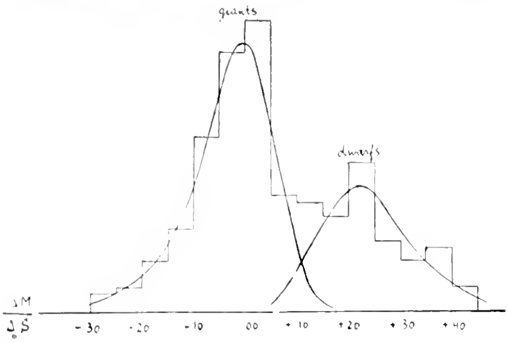


FIGURE 1

Frequency curve of value of $\frac{\Delta M}{\Delta S}$

curve is $-0^M.045$. The dwarf curve on the other hand cannot be used for the dwarf branch without further reduction. From an inspection of the values of $\Delta M/\Delta S$ it is seen that the mean value is nearly constant between *A0* and *K0*, is a little larger than this mean *before A0* and is steadily increasing from *K0* to *Mb*. The mean values for the intervals *B0* to *A0*, *K0* to *Ma* and *Ma* to *Mb* were therefore determined separately, and the mean for *A0* to *K0* found by allowing for these larger values in the general mean derived from the frequency curve.

Arbitrarily assuming the absolute magnitude of a class *A0* star to be $0^M.0$ we get the following mean values for the absolute magnitude at a given spectral class.

TABLE 1

	Dwarfs	Giants
B0	$-2^M.1$	
A0	0 .0	
F0	+2 .0	$-0^M.1$
G0	1 .0	-0 .9
K0	6 .0	-1 .3
Ma	8 .6	-1 .8
Mb	11 .3	

Our next step will be the reduction of these relative values to the commonly accepted system of absolute magnitudes. For this it is necessary to assume that certain physical laws, valid for the *Earth* and the Solar System hold throughout the Universe. It is then possible to obtain the distances of four of the pairs contained in our list viz:

1. *α Centauri.* WRIGHT has determined the parallax by comparing the observed difference in radial velocity of the two components with the computed velocity in angular measure derived from the orbital motion.

2. *α Aurigæ.* MERRILL has derived a parallax from a comparison of interferometer measures with spectroscopic observations.

3. *ξ Urs. Maj.* This star belongs to the *Ursa Major* cluster, and a parallax for all stars belonging to this cluster can be computed from their positions in the sky, their approximate proper-motions and their radial velocities.

4. *θ Tauri.* This star is a member of the *Taurus* cluster and the parallax may be computed in a way similar to that for *ξ UMa.*

Consideration of the absolute magnitudes for these four double stars leads to the conclusion that a correction of $+0^M.57$ needs to be applied to the relative values given in Table I.

The resulting relation between absolute magnitude and spectral class is graphically represented in Figure 2. The mean absolute magnitudes derived from

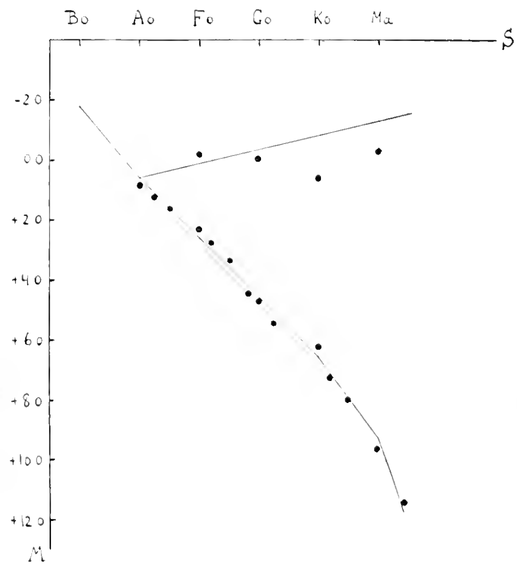


FIGURE 2

Relation between Absolute Magnitude and Spectral Class

trigonometric parallaxes have been inserted as dots. It will be noted that on the dwarf branch the agreement betwen the two sets of data is amazingly close, considering the fact that the broken line was derived without use of a *single* trigonometric parallax.

On the other hand it seems that the trend upwards of our line for the giants is systematically too large. This might have been expected from the fact that we started our investigation without making any assumptions about the existence of giants or dwarfs. Accordingly, stars composed of an early-type dwarf and a late-type giant, giving a large negative value for $\Delta M/\Delta S$ were treated as consisting of two giants. Our solution of the problem has only been made possible by the fortunate circumstance that there are very few pairs composed of a giant and a dwarf. Such combinations accord admirably with the established giant and dwarf branches. As a few examples we cite: *α Herculis*, *F8* dwarf and *Mb* giant, *α Aurigæ*, two *G0* giants and one *Ma* dwarf, ψ_1 *Aquarii*, *K0* giant and *K0* dwarf, *α Tauri*, *K5* giant and probably *M* dwarf. Allowing for the existence of such pairs we might effect a second approximation which will undoubtedly give better results.

The principal conclusions from the present investigation may be summed up as follows:

1. From double star data alone, it is possible to obtain the connection between absolute magnitude and spectral class, thus providing the observational basis for a theory of stellar evolution.

2. At the same time, we can establish a correct system of absolute magnitudes and parallaxes, entirely independent of any trigonometric measures.

May 7, 1923.

OBSERVATIONS OF (3) *JUNO*,

MADE WITH THE 5-INCH MERIDIAN CIRCLE OF THE CINCINNATI OBSERVATORY,

By ELLIOTT SMITH.

Date	G. M. T.	App. α	App. δ	log. $p.\Delta'$		Red. to App. pl.	
	h m s	h m s	° ′ ″			s	″
1922 Nov. 18	17 02 10.42	3 11 15.78	−4 44 37.4	−∞	0.7832	−3.78	− 8.2
1923 Jan. 18	13 03 30.48	3 15 26.60	−0 19 26.4	∞	0.7453	+ .61	10.6
1923 Feb. 8	12 04 22.34	3 38 56.41	+3 33 26.4	∞	0.7067	+ .46	11.5
1923 Feb. 14	11 49 00.04	3 47 10.90	+4 39 33.3	∞	0.6947	+ .44	11.5

THE SPECTRUM OF *ALGOL*,

By IDA BARNEY.

This work on the spectrum of *Algol*, *β Persei*, is based upon the study of about 250 spectrograms secured at the Allegheny Observatory by Dr. Schlesinger and others during the years 1907-1912. These spectrograms were taken on fine grained plates with the Mellon Spectrograph, described in *Allegheny Publications*, Volume 2, page 1, and show the spectrum of *Algol* exceptionally well. The orbital elements for *Algol* have been obtained from these spectrograms by Dr. Schlesinger, and later the complete discussion of these results will be published by him.

When measuring the spectrograms for the determination of elements of the orbit, Dr. Schlesinger used the eight prominent lines that are usually the only ones well visible in the *Algol* spectrum. At the same time he noticed that some of the spectrograms showed many other lines, and that generally those plates taken near the primary minimum showed a great number of extra lines, sometimes as many as eighty or ninety.

Dr. Schlesinger turned these spectrograms over to me for the purpose of measuring the positions of these extra lines and thus discovering if possible their origin. I wish to acknowledge my indebtedness to him for advice and many helpful suggestions during the carrying out of this investigation.

There are three possible sources from which these additional lines in the *Algol* spectrum may come, since they are visible in greatest numbers near the principal minimum when the primary body is partially eclipsed. They may come from the edge of the primary, they may be due to the eclipsing body, or finally they may come from the third body since at the principal minimum the light from that body may form an appreciable part of the total light. According to Professor

STEBBINS' paper (*Astrophysical Journal*, Volume 53, page 117) the third body may have nearly one-third of the total light at minimum.

Each spectrogram of the series was examined and given a weight which indicates approximately the number of lines appearing on that particular plate. A scale of ten has been used, zero meaning that no lines appear except the eight prominent ones used by DR. SCHLESINGER in his paper published in *Allegheny Publications*, Volume 1, page 25. One plate known to show a great many fine lines was assigned the weight ten, and the others weighted accordingly. At the time of the examination of the spectrograms the phases for the various plates were not known to me, so that the weights given were not the result of any previously conceived idea in regard to the relation between the phase and the appearance of these lines.

TABLE 1

Class	Phase	No. of Plates	Mean weight	Reduced weight
1	0.0–0.2	22	5.4	4.4
2	0.2–0.4	19	1.4	0.4
3	0.4–0.6	21	2.2	1.2
4	0.6–0.8	14	0.8	0
5	0.8–1.0	7	0.4	0
6	1.0–1.2	17	0.5	0
7	1.2–1.4	21	2.3	1.3
8	1.4–1.6	14	1.2	0.2
9	1.6–1.8	19	1.7	0.7
10	1.8–2.0	19	3.0	2.0
11	2.0–2.2	15	1.3	0.3
12	2.2–2.4	18	2.0	1.0
13	2.4–2.6	12	1.3	0.3
14	2.6–2.8	20	2.6	1.6
15	2.8–2.9	12	4.8	3.8

After the weights had been assigned, the spectrograms were arranged according to phase and divided into fifteen classes, each class except the last extending over 0.2 days in phase. Table 1 gives the classes numbered from 1 to 15, the limits of phase for each class, the numbers of plates in it, and the mean weight from these plates. Since the whole spectrum of *Algol* includes various other lines beside the eight mentioned above some allowance should be made for these. Excluding the classes 1 and 15 taken during the principal eclipse, it appears that the average plate has a weight of approximately 1.0. That is an average spectrogram taken under favorable conditions at any phase shows enough lines, beside the eight prominent ones, to be given a weight 1.0. Consequently the mean weight reduced by 1.0 may be taken as indicating the presence of the lines for which the origin is sought. These weights are given in the last column of Table 1. This reduction if applied strictly would make the classes 4, 5, and 6 have negative weights but these have been given the weight 0.

As was expected from what was already known about the appearance of these extra lines the classes with the greatest weight included the spectrograms taken near the primary minimum. The classes with the next

TABLE 2

Substance	λ Rowland	Difference, mean λ from plate − λ Rowland	No. of plates on which line was identified
Fe	4045.97	−0.42A	8
Fe	4063.76	+ .03	9
*Fe	4067.28	− .02	8
Fe	4071.91	− .06	6
Fe	4144.04	− .44	12
Ti, Cr	4163.82	− .45	7
	4167.41	− .26	8
Fe	4173.48	+ .44	10
V, —	4179.54	− .10	12
Fe C	4195.78	− .08	7
Fe	4215.58	+ .21	9
Ca	4226.90	+ .01	6
Fe	4233.77	− .35	15
Fe	4242.90	− .22	6
Fe	4271.93	− .08	7
Fe	4282.56	− .09	11
Ca	4289.52	+ .27	10
Fe	4294.30	− .01	8
Ti, Fe	4299.41	− .20	6
*Ti	4300.17	− .19	6
Ca	4302.69	+ .23	6
Fe	4308.08	− .21	9
Fe	4309.54	− .04	9
Fe	4315.26	− .23	9
Sc	4320.91	+ .18	7
Fe	4325.94	− .06	8
Fe	4388.57	− .08	7
*Ti,V,Zr	4395.31	+ .07	11
Fe	4404.93	− .01	8
Fe	4454.55	+ .33	6
Fe	4508.46	+ .12	6
	4515.51	− .44	6
Ti Co	4534.14	+ .46	11
Fe	4549.64	− .00	17
Fe Cr	4556.31	− .18	8
Ti	4572.16	− .06	8
Fe	4584.02	+ .06	13

*Blend of two lines.

largest weights were those on either side of the secondary minimum, that is classes 7 and 10, as this minimum occurs between the phases 1.4 and 1.6. (*Astrophysical Journal*, Volume 53, page 118). This led to the conclusion to be discussed more in detail later that the lines are due in part to the secondary and in part to the primary.

Twenty of the spectrograms that showed the additional lines especially well were measured and radial velocities obtained from as many lines as possible. The plates were measured on a Gærtner engine for which it was necessary to obtain the dispersion curve before reducing the spectrograms. (*Allegheny Publications* Volume 1, page 14.) The equation obtained for this curve from the comparison spectrum was

$$(\lambda - 2300.96)\ (R - 148.000) = 104915.6$$

where λ is the wave length, and R the screw reading in millimeters. Using this formula and a set of lines from the comparison spectrum of titanium with wavelengths given in ROWLAND'S Table, a table giving $\Delta\lambda$ for varying R was constructed. The final formula giving the relation between λ and R was that given above where $\lambda + \Delta\lambda$ replaced λ. From this relation normal values of R were calculated for the particular comparison lines used in measuring these spectrograms, and for the eight principal star lines. For each plate the values of R for all the star lines were corrected from the curve depending upon the normal R and the measured R for the comparison lines. For the star lines to be identified λ was calculated from the formula already given and that value of λ, corrected for the *Earth's* motion, was compared with the wave length given in ROWLAND'S Table. From this difference the radial velocity was found in the usual way.

Thirty-seven lines were found for which the wavelengths as determined on five or more plates agreed sufficiently well with the wave-length in ROWLAND'S Table to allow the line to be considered as identified. These lines are given in Table 2. The majority of them are iron lines.

From these lines radial velocities were obtained. The radial velocity for each plate was taken as the straight mean of those from individual lines. These velocities are given in the next to the last column of Table 3, and the number of lines used to derive this velocity is given in the last column. Table 3 has the spectrograms arranged according to phase and gives the velocity for each plate obtained from the velocity curve given in *Allegheny Publications*, Volume 1, page 31, as well as the date on which the spectrogram was taken and the number of the plate given it at the time it was taken. In general the velocities from these additional lines have the same sign as the velo-

TABLE 3

No. of Plate	Date, G. M. T. h m	Phase days	Velocity from Primary	Velocity from extra lines	No. of lines used
2168	1908 Nov. 12, 16 01	0.020	− 6km	− 2km	22
4898	1911 Oct. 26, 18 42	0.027	− 6	+ 2	22
1089	1908 Jan. 16, 15 37	0.065	−10	− 2	19
1168	1908 Feb. 8, 14 12	0.067	−10	− 7	18
2180	1908 Nov. 15, 14 04	0.072	−10	− 9	21
1090	1908 Jan. 16, 16 02	0.082	−11	− 3	23
2181	1908 Nov. 15, 14 55	0.106	−14	− 9	18
1133	1908 Jan. 25, 13 38	0.381	−32	− 9	12
991	1907 Nov. 15, 16 36	1.190	−22	− 8	10
2214	1908 Nov. 25, 11 40	1.193	+ 5	− 1	9
2057	1908 Oct. 13, 17 11	1.609	+17	+ 1	9
2059	1908 Oct. 13, 17 46	1.631	+17	+ 3	15
1161	1908 Feb. 4, 15 01	1.838	+30	+15	7
2257	1908 Dec. 27, 12 55	1.879	+32	+ 6	17
2106	1908 Oct. 28, 17 04	2.266	+37	+ 4	9
3347	1910 Jan. 10 14 06	2.411	+30	+12	5
2039	1908 Oct. 11, 20 25	2.609	+16	− 3	5
2166	1908 Nov. 12, 14 55	2.841	0	+ 1	31
5073	1912 Feb. 15, 13 44	2.856	− 1	− 2	19
2167	1908 Nov. 12, 15 30	2.865	− 2	0	25

cities from the velocity curve. When this curve gives a small velocity, the velocities from the other lines are very near zero. At other phases these velocities are considerably smaller than the velocity from the curve.

From a consideration of the number of lines visible at the various phases, and the velocities found from those identified lines we may conclude that the extra lines are due to the combined effect of the light from the primary and that from its eclipsing companion.

These lines appear during the primary minimum for two reasons: first, because then the velocities of the two bodies are nearly the same so that light waves of the same length coming from the two bodies unite and make visible lines in the spectrum of the primary which were not visible at other times; and second, the reduction in brightness of the continuous spectrum of the primary gives the light of the secondary more opportunity to produce an effect on the spectrum.

As the time of secondary minimum approaches conditions are again more favorable for the appearance of these lines, as the difference in the velocity of the two bodies is becoming less so the light of the same wavelength from the different bodies again combines to produce visible lines. At this time the secondary has its brightest side toward the earth, which increases very slightly its share in the total light of the system. However, the secondary is now the body eclipsed, so that during the secondary minimum there should be l'ttle or no trace of light from this body. This fact is brought out in Table 1 where the weights for classes 8 and 9 are decidedly smaller than for 7 and 10.

Fewest additional lines appear at times when the two bodies have velocities differing the most. At such times if it were possible to get a spectrogram showing these lines, they should be double. However, the ratio of the light received from the secondary and from the primary is so small, approximately 1:15, (*Astrophysical Journal*, Volume 53, page 116) that the spectrum of the secondary cannot be photographed.

It is evident that these lines are just on the border of visibility, for the number of lines that appear on any one plate varies greatly. It is only when all the conditions affecting a plate are favorable that a spectrogram shows a great number of lines. Two spectrograms taken within one hour do not show exactly the same lines, although the majority of the lines on the two plates are the same.

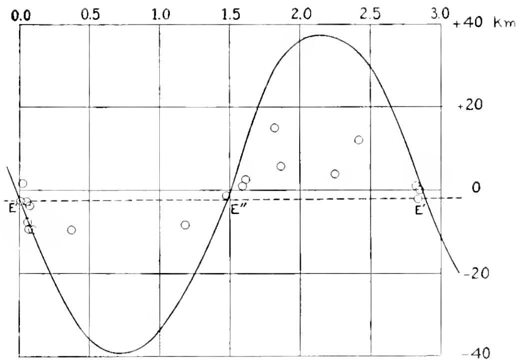
The fact that the velocities of Table 3 agree in sign with the velocities of the primary indicates that this body must have some part in producing these, while at the same time the reduced range of these velocities shows that its light alone cannot produce these lines.

This agreement of sign between the two sets of velocities holds true independently of the season in which the spectrogram was taken. Furthermore there appears to be no indication that the lines come from the third body in the system. If light from this body were the source of these lines, then the velocity would show some change if obtained from spectrograms taken several months apart, as the period of this body is a little less than 1.9 years. The spectrograms do not give any indication of such variation.

The majority of the lines identified are iron lines. It is interesting to consider some of the individual lines. There are in the list four, 4141.04, 4173.48, 4179.54, and 4233.77, which are generally present in the *B8* type spectrum, and one, 4226.90, characteristic of the type *A2*. Then there are five, 4299.41, 4300.47, 4302.69, 4308.08, 4309.54 and 4315.26, belonging to band *G* which begins to appear in the usual spectrum of type *A5*, and is prominent in *F5*. Also the lines of band *G* appear more numerously on the spectrograms taken near the primary minimum when the light from the secondary is relatively the most effective. On only two of the spectrograms measured no lines of band *G* were identified. On one of these, No. 991, taken just before the secondary minimum one line was measured in this region, but the value of λ obtained for it was such that it could not be positively identified. On the other one, No. 2214, taken during the secondary eclipse, no lines at all appear in this region. This agrees with the theory that these lines need to be reenforced by light from the secondary to make them visible, since at this time, practically all the light from it is cut off.

The presence of these lines belonging to band *G* and of the other iron lines seems to indicate for the secondary a spectral type slightly later than *B8*. In the article already mentioned, PROFESSOR STEBBINS states that although the difference between the photographic and visual light at the secondary minimum would indicate a spectrum of approximately *G0*, there are too many uncertain factors involved to make any definite classification except to say that the secondary is a yellower star than the primary. The results obtained here would place the spectrum in the class *A* or *F*, rather than *G*, which, however, agrees with the idea that the secondary is the yellower star.

Summarizing the results of the preceding pages, it may be said that these extra lines belong to the spectrum of the primary in the *Algol* system as well as to that of the secondary, and furthermore they are relatively more intense in the former than in the latter. At the same time these lines are just on the border of visibility in the spectrum of the primary and do not



The curve represents the orbital velocity of the Bright Star. The horizontal dotted line corresponds to the velocity of the center of mass of Bright Star and its Eclipsing Companion. Principal minimum occurs at E', secondary minimum at E''. The circles represent velocities from the Extra Lines.

N. B. This diagram should be inserted in *A. J.* No. 828 to accompany the article on "The Spectrum of *Algol*," by Miss Ida Barney.— *Editor.*

appear unless the light from this body is reenforced by that from the eclipsing companion. Since these extra lines are so many of them iron lines their presence suggests a spectral type later than *B8*, not only for the secondary but also for the primary body itself.

Yale University Observatory,
31 May, 1923.

CORRIGENDA, VOÛTE'S FIRST CATALOGUE OF RADIAL VELOCITIES,

By MARGARETTA PALMER.

Cat. No.	Column	Corrigenda	
40	Decl.	For −	Read +
65	Star	*Hydrae*	*Hydri*
159	R. V.	−167	−16.7
162	R. V.	+183	+18.3
164	R. V.	−207	−20.7
171	R. V.	−143	−14.3
219	Star	*Pegasi*	*Persei*
316	Decl.	4′	48′
334	Decl.	8°	80°
426	R. V.	−234	−23.4
474	Star	ψ *Aurigæ*	χ
484	Magn.	4.7	5.6
491	Star	ψ_2	φ^2
526	Star	κ_1	χ_1
589	Star	*Phoenicis*	*Pictoris*
709	Star	κ	χ
723	Star	8^h321	7^h321
752	Magn.	4.5	6.0
752	R. V.	+27.9	+25.2
752	Observatory	W	*Orbit*
753	Magn.	5.5	7.2
753	R. V.	+24.2	+27.9
753	Observatory	*Orbit*	W
776	R. V.	+24.1	+27.6
808	R. A.	$7.^m9$	$7.^m6$
843	R. A.	$27.^m0$	$28.^m0$
928	Star	*Garina*	*Carina*
974	Magn.	4.8	4.0
977	R. V.	+2.4	−2.4
1020	Magn.	5.1	6.8
1189	R. V.	−11.6	−1.6
1196	Should be P.G.C. 3699 τ Lupi, 14^h $19.^m7$ −44° 16′, magn. 4.6, Spectr. B3, R. V. −16.6		
1211	R. V.	For +22.2	Read −22.2
1216	Observatory	L	P
1429	Magn.	5.3	4.6 (combined magn.)
1429	R. V.	−5	+1.2 (velocity of centre of mass of visual system)
1464	Star	17^h 517	17^h 514
1467	Star	ν	ν_1
1511	Spectr.	A	G
1511	R. V.	−27	−29.6
1512	Spectr.	G	A
1512	R. V.	−29.6	−27
1518	Decl.	14°	19°

Cat. No.	Column	Corrigenda	
1534	Star	For 6576	Read 6567
1609	Magn.	5.0	4.5
1639	Decl.	19	9′
1680	Star	B.D. +30° 3539	+30° 3639
1684	Observatory	D	L
1692	R. A.	18^h	19^h
1718	Decl.	4′	43′
1747	Decl.	+	−
1797	R. V.	+85	+8.5
1798	R. V.	−26	−2.6
1829	R. V.	−7.3	−73
1849	Star	W.B. 2^h97	W.B. 21^h97
1852	R. V.	−69	−6.9
1880	R. A.	01^h	21^h
1883	Observatory	Plates were taken at L, measured at D	
1886	R. V.	For −18.6	Read −38.6
1914	R. A.	$57.^m4$	$57.^m7$
1999	R. V.	−19	−1.9
2005	R. V.	−11.3	−11.8
p. 168	Note 18	For −12.	Read −26.
Boss P.G.C.			
1054	Decl.	For 19′	Read 59′
1525		Already included on p. 149	
1635		Already included on p. 120	
224	Decl.	For −	Read +
1730	Star	13	12
2087	Star	*a*	a
		OΣ 82. Erase this line. See star following P.G.C. 1000 p. 171.	
2984	Decl.	For 16′	Read 6′
3699		Should be P.G.C. 3700 τ_2 *Lupi*, Decl. −44° 56′	
4147	Star	For γ	Read ν
4158		Already included on p. 145	
	Star following 4650 should be P.G.C. 4785, R. A. 18^h $19.^m4$ instead of 18^h $19.^m7$		
4664	Star	μ *Lyrae*	
4664	Decl.	For 29′	Read 39′
4862	Decl.	3′	39′
5018	Decl.	34	44
5073		Already included on p. 156	
5213	Star	For 5	Read 35
5593	Decl.	25° 11′	58° 19′
5687	Star	19 *Cephei*	
	Star	For *Lal.* 36867	Read 16867

Yale University Observatory,
Feb. 12, 1923.

CONTENTS.

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THE

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OBSERVATIONS OF COMET 1922*c* (BAADE),

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

BY ASAPH HALL AND ERNEST CLARE BOWER.

[Communicated by Rear Admiral W. D. MCDOUGALL, U. S. Navy, Superintendent of U. S. Naval Observatory.]

G. M. T.		App. α	App. δ	☄ − ★		Comp.	log $p\rho$		Ap.pl. red. of ★		Seeing	Obs.	★
		h m s	h m s	s	′ ″				s	″			
1922	21.58784	19 57 58.06	+36 18 59.4	+ 1.36	3 58.2	*d*10, 8	9.623	0.231	+1.84	+32.6	f	H.	1
Oct.	25.60735	20 0 16.11	+36 1 20.9	− 33.30	−14 29.8	*d*10, 8	9.667	0.332	+1.85	+32.7	p f	H.	2
	26.63813	20 2 37.12	+35 13 31.1	− 52.62	− 2 25.0	*d*10, 8	9.711	0.160	+1.86	+32.7	p f	H.	3
	27.62224	20 4 52.76	+35 26 26.8	+ 23.24	− 3 36.0	*d*10, 8	9.692	0.111	+1.86	+32.6	p	H.	4
	30.61295	20 11 49.85	+34 34 32.4	+ 25.13	1 18.2	*d*10, 8	9.678	0.105	+1.86	+32.5	f	H.	5
Nov.	8.58084	20 33 20.28	+31 59 30.8	31.56	− 5 13.3	*d*12, 8	9.623	0.378	+1.93	+32.5	p	H.	6
	10.54432	20 38 9.17	+31 25 59.9	+ 21.11	+ 2 21.3	*d*10, 8	9.525	0.280	+1.94	+32.4	f	H.	7
	10.59552	20 38 16.83	+31 25 7.3	− 5.82	7 26.2	*d*10, 10	9.654	0.111	+1.95	+32.1	f	H.	8
	15.62332	20 50 13.56	+30 0 28.1	+ 90.76	1 2.0	*l*20, 4	9.693	0.519	+1.96	+32.0	p	H.	9
	16.56302	20 53 17.21	+29 11 29.1	− 11.09	−10 30.0	*d*10, 8	9.590	0.395	+1.99	+32.1	f	H.	10
	21.55036	21 5 33.18	+28 23 13.4	+ 15.74	6 18.5	*d*10, 8	9.565	0.103	+2.04	+31.8	f	B.	11
Dec.	6.53964	21 43 9.16	+24 10 35.8	− 17.02	− 5 59.0	*d*10, 8	9.562	0.481	+2.18	+30.3	f	B.	12
	8.48151	21 47 59.67	+24 11 27.4	− 18.99	− 5 16.8	*d*10, 8	9.345	0.396	+2.20	+30.1	p	B.	13
	13.52972	22 0 28.78	+23 9 33.4	+ 20.56	7 37.3	*d*10, 8	9.549	0.500	+2.22	+29.3	g	B.	14
	26.51921	22 31 55.38	+20 15 20.8	− 9.62	+ 1 19.8	*d*10, 8	9.550	0.540	+2.34	+27.3	f	B.	15
1923	29.51535	22 39 1.83	+20 16 29.9	− 9.16	+ 9 31.0	*d*10, 8	9.612	0.588	+2.36	+26.7	p	B.	16
Jan.	5.50407	22 55 15.86	+19 16 18.2	+ 1.62	− 1 19.8	*d*11, 10	9.536	0.555	−0.52	+ 6.5	f	B.	17
	12.50706	23 11 9.13	+18 25 36.0	−184.75	+ 7 1.9	*l*20, 5	9.561	0.580	−0.51	+ 1.7	p	B.	19
	17.49101	23 22 12.85	+17 51 18.5	+ 11.15	− 5 35.0	*d*10, 8	9.535	0.575	−0.50	+ 3.8	g	B.	20
	22.50947	23 33 8.98	+17 26 18.3	− 3.90	+ 5 51.3	*d*10, 8	9.590	0.607	−0.51	+ 2.6	p	B.	21
Feb.	16.52473	0 21 39.61	+15 58 33.0	+ 2.81	+ 0 6.0	*d*10, 10	9.651	0.672	−0.51	− 1.9	p	B.	22

Oct. 24. 9ᵐ, not visible in 5-in. Coma. Oct. 25. 10ᵐ, visible in 5-in. Coma. Oct. 26. 11ᵐ, visible in 5-in. Coma. Oct. 27. 10ᵐ, not sure of visibility in 5-in. Windy. Oct. 30. 11ᵐ. Coma. Moonlight. Nov. 8. Perhaps 10ᵐ. Windy. Haze. Close to faint star at first. Nov. 10.54. 10ᵐ. Coma, diffuse. Nov. 10.59. Faint at last. Haze. Nov. 15. Very faint at times. Clouded. Nov. 16. 11ᵐ. Coma. Nov. 21. Just visible in 5-in. Dec. 6. Visible in 5-in. Dec. 8. 10ᵐ. Visible in 5-in. Dec. 13. Visible in 5-in. Dec. 26. Moonlight. Dec. 29. Moonlight. Jan. 5. Faint. Clouds. Jan. 12. Windy. Jan. 17. The *X*-coördinate of the comparison star seems to need the correction +1, which has been applied. Jan. 22. Faint. Moonlight. Haze.

Mean Places of Comparison Stars for Beginning of Year

★	α	δ	Authority
	h m s	° ′ ″	
1	19 57 51.86	+36 22 25.0	*A. G. Lund* 8930
2	20 0 17.86	+36 12 18.0	*A. G. Lund* 8974
3	20 3 27.88	+35 15 21.3	*P. G. C.* Boss 5157
4	20 4 27.56	+35 29 30.2	*A. G. Lund* 9036
5	20 11 22.56	+34 38 48.1	*A. G. Leiden* 8082
6	20 33 19.91	+32 1 11.6	*A. G. Leiden* 8350
7	20 37 13.09	+31 23 6.2	*Astr. Oxf.* +31.2037, 60744
8	20 38 20.70	+31 32 1.1	*A. G. Leiden* 8410
9	20 49 10.84	+30 3 58.7	*A. G. Camb.* 11863
10	20 53 29.34	+29 54 27.6	*A. G. Camb.* 11933
11	21 5 15.70	+28 29 30.1	¼ { *Astr. Oxf.* +28.2100, 63232 *Astr. Oxf.* +28.2109, 63961 *Astr. Oxf.* +29.2101, 60903 *A. G. Camb.* 12172 }
12	21 13 24.30	+24 46 5.4	½ *Astr.* { *Par.* +24.2141, 116 *Oxf.* +25.2140, 74527 }
13	21 18 16.46	+24 19 13.8	*Abbadia A* 12937
14	22 0 6.00	+23 16 41.4	½ *Astr. Par.* { +23.2156, 253 +24.2200, 312 }
15	22 32 2.66	+20 43 3.7	*Astr. Par.* +21.2228, 400
16	22 39 11.63	+20 6 32.2	*Abbadia A* 13422
17	22 55 11.76	+19 18 1.5	*B. D.* +18.5080 comp. with 18, 1923 Jan. 17, $\Delta\alpha = -3^m\ 18^s.69$, $\Delta\delta = +1'\ 42''.6$, 1923.0
18	22 58 33.15	+19 16 18.9	*Abbadia A* 13624
19	23 11 14.39	+18 18 26.4	*Abbadia A* 13763
20	23 22 2.20	+17 59 19.7	*Astr. Bor.* +17.2324, 43
21	23 33 13.39	+17 20 51.4	*Abbadia A* 13946
22	0 21 37.31	+15 58 28.9	½ *Astr. Bor.* { +15.0020, 46 +16.0024, 166 }

U. S. Naval Observatory, Washington, D. C.,
1923, Aug. 15.

OCCULTATIONS OF *VENUS* AND *ALDEBARAN*.

By CHARLES CLAYTON WYLIE.

The occultation of *Venus* on the morning of January 13, 1923, was observed at the University of Illinois Observatory by C. C. Wylie, S. L. Neave, and C. B. Schmeltzer; and the daylight occultation of *Aldebaran* on the afternoon of April 19 was observed by C. C. Wylie and C. B. Schmeltzer. The times were taken on stop-watches, which were promptly compared with the Riefler clock, and its correction was in turn determined by the Annapolis wireless signals. Corrections for rate of stop-watch were applied where appreciable. Presumably the uncertainty of clock correction on both days is much less than observational error.

Conditions were fairly good for the occultation of *Venus*, but bad seeing made the contact with south cusp somewhat uncertain, and at emersion the brilliancy of *Venus* made the limb of the moon invisible, thus increasing the uncertainty of the time for contact with the limb, especially for the small telescope.

At the occultation of *Aldebaran*, thin clouds interfered some, and the star was a little faint for observa-

tion with the smaller instrument, but appeared quite bright in the 12-inch.

The observed Greenwich mean times of the various phenomena follow:

	G. M. T.	Inst. Obs.	Remarks
Venus immersion	1923 h m s		
Contact south cusp	Jan. 12 23 13 23 5	12-inch, WYLIE	± 3 seconds
Contact south cusp	13 17 9	4-inch, NEAVE	± 5 seconds
Contact limb	14 39.0	12-inch, WYLIE	±0 2 seconds
Contact limb	14 39 1	4-inch, NEAVE	±0 3 seconds
Contact limb	14 39 2	2¼-inch, SCHMELTZER	±0 3 seconds
Venus emersion			
Contact north cusp	Jan. 13 0 14 51 4	12-inch, WYLIE	late ±0 5 seconds
Contact north cusp	14 52 2	4-inch, NEAVE	late ±0 5 seconds
Contact limb	16 15 9	12-inch, WYLIE	± 2 seconds
Contact limb	16 14 5	4-inch, NEAVE	± 4 seconds
Contact limb	16 22 3	2¼-inch, SCHMELTZER	± 8 seconds
Aldebaran			
Immersion	Apr. 19 9 58 29 0	12-inch, WYLIE	late ±0.2 seconds
Emersion	11 22 18 6	12-inch, WYLIE	late ±0 2 seconds
Emersion	22 18 9	3-inch, SCHMELTZER	late ±0 3 seconds

University of Illinois Observatory,
1923, May 25.

OBSERVATIONS OF COMETS,

MADE WITH THE 16 CM. REFRACTOR (RING MICROMETER) OF THE TOKYO ASTRONOMICAL OBSERVATORY,

BY SIGERU KANDA.

1922	G. M. T.	Δα	Δδ	Comps.	α App.	δ App.	log pΔ		Red. to App. Pl.		★
					Comet 1922 *c* (BAADE)						
	h m s	m s	′ ″		h m s	° ′ ″			s		
Nov. 9	22 42 20	−0 35 03	−1 30 7	10, 10	20 36 41 64	+31 36 11 3	9 5561	0 1675	+1 95	+32 4	1
17	22 3 8	+1 20 45	−0 30 8	10, 10	20 56 27 89	+29 22 35 2	9 4752	0 1763	+1 99	+32 0	2
19	22 44 28	−0 39 88	+2 3 8	16, 16	21 1 32 42	+28 49 38 5	9 5790	0 2989	+2 03	+31 9	3
26	23 24 26	+1 39 56	−1 13 5	8, 8	21 19 11 92	+26 59 1 7	9 6507	0 4411	+2 07	+31 2	4
Dec. 21	21 46 42	+1 45 87	+0 42 6	12, 12	22 20 53 90	+21 32 55 0	9 5302	0 4425	+2 28	+28 1	5
					Comet 1922 *d* (SKJELLERUP)						
Dec. 2	7 6 48	−1 10 42	+2 51 8	8, 8	11 31 25 78	−16 22 15 9	*n*9.4612	0 8153	+2 55	−10 4	6

Comparison Stars

★	α 1922.0	δ 1922.0	Authority	★	α 1922.0	δ 1922.0	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	20 37 14 72	+31 37 9 6	*A. G. Leiden* 8394	4	21 17 30 29	+26 59 41 0	*A. G. Cambr. (Engl.)* 12388
2	20 55 5.45	+29 22 34 0	*A. G. Cambr. (Engl.)* 11968	5	22 19 5 75	+21 31 41 3	*A. G. Berlin B.* 8615
3	21 2 10 27	+28 47 2 8	*A. G. Cambr. (Engl.)* 12103	6	11 32 33 65	−16 24 57 3	*A. G. Washington* 1516

PHOTOGRAPHIC POSITIONS OF COMET 1922*d* (SKJELLERUP),

obtained with the 20 cm. photographic refractor

1922	G M T	Astrographic α 1922	Astrographic δ 1922	Aberration		log $p\Delta$		Comparison Stars
	h m	h m s	° ′ ″	s	″			
Nov. 29	7 11	1 44 15 22 35	−13 27 37 1	−0 25	+7 8	*n*9 3313	0 8103	*A.G.Camb.(U.S.)* 4220-46-49-54-55-58-84
Dec. 11	6 51	9 42 23 7 02	−24 40 41 2	−0 41	+9 6	*n*9 5570	0 8331	*Cordoba A.* 9352-75-92-93, 9415-38

Photographs were taken by M. TODA. Measurements and reductions by S. KANDA.

Tokyo Astronomical Observatory, Tokyo, Japan,
Jan. 20, 1923.

OBSERVATIONS OF COMETS,

MADE WITH THE 16-INCH REFRACTOR OF THE CINCINNATI OBSERVATORY,

By EVERETT I. YOWELL AND ELLIOTT SMITH.

1921	G M T	No. Comp	Δα	Δδ	☄'s apparent α	☄'s apparent δ	log $p.\Delta$		★	Obs.
			Comet PONS-WINNECKE (1921*b*)							
	h m s		m s	′ ″	h m s	° ′ ″				
Apr. 27	15 15 47	6, 6	+ 08.49	+5 03.3	16 38 35.69	+42 44 45.9	9.764*n*	0.388	1	Y
29	16 28 26	0, 8		−6 41.8		+43 20 07.4		9.948	2	Y
29	16 40 44	4, 0	+ 5.82		16 45 24.24		9.688*n*		2	Y
May 5	16 15 25	8, 8	+ 11.74	− 8 23.7	17 08 05.71	+44 58 56.9	9.718*n*	0.031	3	Y
15	19 56 01	6, 6	+ 8.85	+ 1 43.8	18 00 26.24	+46 28 42.4	9.434*n*	0.019*n*	4	Y
June 1	18 41 45	16, 6	+ 39.65	− 4 44.4	20 29 12.10	+38 16 12.1	9.581*n*	0.064	5	S
2	19 28 54	12, 5	− 3.45	− 7 10.9	20 41 06.56	+36 42 42.8	9.470*n*	9.972	6	S
4	20 24 18	18, 6	+ 25.33	+ 4 27.4	21 03 26.05	+33 28 37.0	9.294*n*	0.037	7	S
12	18 41 09	6, 6	− 12.03	− 9 04.0	22 25 42.36	+16 49 06.4	9.612*n*	0.636	8	Y
			Comet REID (1921 *a*)							
Apr. 27	18 02 51	6, 6	−1 14.84	+11 10.8	20 53 06.73	+51 48 14.9	9.867*n*	0.549	9	Y
29	17 19 46	8, 8	− 0.34	− 3 10.8	21 00 24.66	+58 57 55.6	9.945*n*	0.519	10	Y
May 5	17 34 35	7, 7	− 28.49	− 6 05.2	22 03 58.31	+78 43 29.2	0.345*n*	0.502	11	Y
15	18 12 12	6, 6	0.26	− 1 25.1	7 18 06.49	+75 37 30.3	0.147	0.754	12	Y
June 2	15 19 10	8, 9	+1 12.41	+ 2 50.8	8 03 56.45	+55 46 12.4	9.897	0.642	13	S
4	14 51 36	14 10	+ 29.78	− 4 47.0	8 05 24.34	+54 26 20.5	9.894	0.508	14	S
			Comet BAADE (1922*c*)							
1922										
Nov. 7	13 17 32	12,10	−0 45.39	+ 2 02.5	20 30 53.25	+32 46 46.0	9.551	0.284	15	Y
9	13 35 23	8, 7	1.58	− 1 03.4	20 35 45.56	+31 42 44.9	9.528	0.282	16	Y
10	13 43 39	7, 7	9.37	− 7 00.9	20 38 12.40	+31 25 32.7	9.548	0.309	17	Y
18	14 31 49	8, 8	16.78	− 8 36.4	20 58 10.73	+29 44 48.6	9.638	0.473	18	Y
21	14 31 47	8, 8	+ 7.71	+ 2 00.6	21 05 42.04	+28 22 49.7	9.643	0.497	19	Y
22	15 47 46	8, 9	− 10.82	+ 5 01.4	21 08 17.00	+28 06 32.7	9.684	0.572	20	Y

1922	G. M. T.	No. Comp.	Δα	Δδ	☄'s apparent α	☄'s apparent δ	log p. Δ		★	Obs.
				Comet Baade (1922c) (Continued)						
	h m s		m s	″	h m s	° ′ ″				
Nov. 23	14 17 38	6, 6	+ 1.45	− 41.5	21 10 41.58	+27 51 22.1	9.624	0.482	21	Y
28	12 15 27	8, 8	+ 13.10	+ 1 33.6	21 23 03.32	+26 35 49.4	9.346	0.339	22	Y
29	13 03 52	8, 8	− 7.63	− 12.5	21 25 38.91	+26 20 22.8	9.499	0.410	23	Y
Dec. 5	14 20 39	8, 8	+ 7.28	− 27.6	21 40 18.30	+24 53 33.4	9.637	0.551	24	Y
10	14 26 13	8, 8	+ 25.24	− 4 25.0	21 53 15.13	+23 46 36.5	9.647	0.579	25	Y
12	13 06 09	8, 8	− 4.20	− 19.4	21 58 03.19	+23 21 50.7	9.531	0.492	26	Y
19	13 40 13	8, 8	− 4.13	− 32.8	22 15 14.26	+21 58 20.2	9.603	0.562	27	Y

Mean Places of Comparison Stars for 1921.0 or 1922.0

★	α	Red. to App. Pl.	δ	Red. to App. Pl.	Authority
	1921.0		1921.0		
	h m s	s	° ′ ″	″	
1	16 38 24.97	+ 2.23	+42 36 49.5	− 6.9	1 : 2 (*A. G. Bonn* 10673 cor'd + Monnichmeyer 1331)
2	16 45 16.11	+ 2.25	+43 26 58.3	− 6.1	C_{pa} 3246 p.m. + .001, ″.06
3	17 07 51.66	+ 2.31	+45 07 25.6	− 5.0	*A. G. Bonn* 10995, cor'd by Monnichmeyer
4	18 00 14.94	+ 2.15	+46 27 01.2	− 2.6	*B. D.* 46°.2409 tied to *A. G. Bonn* 11616
5	20 28 59.94	+ 2.51	+38 20 55.5	+ 1.1	*A. G. Lund* 9467
6	20 41 07.52	+ 2.49	+36 19 51.9	+ 1.8	*A. G. Lund* 9636
7	21 02 58.26	+ 2.46	+33 27 07.3	+ 2.6	*A. G. Leiden* 8740
8	22 25 52.13	+ 2.26	+16 28 02.8	+ 7.6	*A. G. Ber. A.* 9196
9	20 54 20.39	+ 1.18	+51 36 38.0	− 6.9	*A. G. Harvard* 6838
10	21 0 23.81	+ 1.19	+59 01 44.0	− 7.6	*A. G. Hels.* 14849
11	22 01 26.01	+ 0.79	+78 49 12.0	− 7.6	*Gr. Astg.* +78°.6984
12	7 18 06.44	+ .01	+75 44 52.9	+ 2.8	*Gr. Astg.* +75°.3448
13	8 05 08.30	+ .56	+55 43 23.8	− 2.2	*A. G. Hels.-Gotha* 5114
14	8 04 54.01	+ .56	+54 28 10.3	− 2.8	*A. G. Harvard* 3055
	1922.0		1922.0		
15	20 31 36.71	+ 1.93	+32 14 44.2	+32.3	1 : 3 (*A. G. Leid* 8326 + *Pots. Astg.* 138, 445 + *Pots. Astg.* 297, 378)
16	20 35 48.20	+ 1.94	+31 43 12.6	+32.4	Connected with *Pots. Astg.* 138,248: Δα +19ˢ.34, Δδ +3′ 03″.6
17	20 38 19.83	+ 1.94	+31 32 01.2	+32.4	1 : 3 (*A. G. Leid* 8440 + *Pots. Astg.* 138, 362 + *Pots. Astg.* 139, 13)
18	20 58 25.50	+ 2.01	+29 19 22.7	+32.0	1 : 3 (*A. G. Cambr.* 12017 + *Ox. Astg.* 29°.60448 + *Ox. Astg.* 30°.63263)
19	21 05 32.29	+ 2.01	+28 20 47.3	+31.8	1 : 3 (*Ox. Astg.* 29°.60858 + *Ox. Astg.* 28°.63929 + *Ox. Astg.* 28°.63160)
20	21 08 25.77	+ 2.05	+28 00 59.9	+31.7	1 : 2 (*Ox. Astg.* 28°.63821 + *Ox. Astg.* 27°.61791)
21	21 10 38.08	+ 2.05	+27 51 31.9	+31.7	1 : 3 (*A. G. Cambr.* 12269 + *Ox. Astg.* 27°.61762 + *Ox. Astg.* 28°.63769)
22	21 22 18.12	+ 2.10	+26 33 44.7	+31.1	1 : 3 (*A. G. Cambr.* 12492 + *Ox. Astg.* 26°.72369 + *Ox. Astg.* 27°.62679)
23	21 25 44.43	+ 2.11	+26 20 01.3	+31.0	1 : 2 (*Ox. Astg.* 27°.62617 + *Ox. Astg.* 26°.73018)
24	21 40 38.86	+ 2.16	+24 53 30.6	+30.4	1 : 2 (*Ox. Astg.* 25°, 71561 + *Par. Astg.* +24°, 21ʰ36ᵐ, 304)
25	21 52 17.69	+ 2.20	+23 50 31.7	+29.8	1 : 2 (*Par. Astg.* 24°, 21ʰ52ᵐ, 198 + *Par. Astg.* 23°, 21ʰ48ᵐ, 342)
26	21 58 05.16	+ 2.23	+23 21 40.7	+29.4	1 : 2 (*A.G.Ber. B* 8189 + *Par. Astg.* 24°, 22ʰ0ᵐ, 268)
27	22 15 16.10	+ 2.29	+21 58 24.4	+28.6	1 : 2 (*Par. Astg.* 22°, 22ʰ16ᵐ, 195 + *Par. Astg.* 21°, 22ʰ12ᵐ, 232)

COMPARISON OF TIME DETERMINATIONS WITH DIFFERENT INSTRUMENTS,

By J. C. HAMMOND and C. B. WATTS.

[Communicated by Captain W. D. MacDougall, U. S. Navy, Superintendent, U. S. Naval Observatory]

In the *Monthly Notices* of the Royal Astronomical Society for January, 1922, Prof. R. A. Sampson calls attention to the fact that time determinations made at various observatories show considerable fluctuations, when compared by means of radio signals. With a view to determining whether such fluctuations are due to causes peculiar to a particular instrument, time has been determined at the Naval Observatory with two instruments since November 9, 1922.

These instruments are the six-inch transit circle and one of the Prin portable transits, which has an aperture of three inches. The former has been used to determine the time at the Naval Observatory for the last twelve years; the latter was used in the determination of the difference in longitude between Washington and Paris in 1913-14. Both instruments are equipped with self-registering micrometers, that of the Prin being driven by a motor. A reversing prism was used on the six-inch throughout, and on the Prin after May 1. The instrument houses are about 300 feet apart and are of different types of construction. The six-inch house has a shutter opening of about 3½ feet, while the roof of the Prin house is rolled off when observing is in progress.

The same stars were observed on both instruments each night and the transits were recorded on the same chronograph, so that the comparison is not affected appreciably by any lag of relays. The Prin transit was reversed on every star and readings of the spirit level and also of the mark were taken between stars. The six-inch was reversed about once a month until February 22, and afterwards between successive time determinations. The time stars were all within 18 degrees of the zenith, and about the same number of stars were observed north and south of the zenith each night, so as to eliminate any error in the azimuth. The latter was determined from observations of circumpolar stars.

The irregularities in the pivots of the Prin transit were measured with an axial microscope and found to be too small to produce any appreciable effect on the time determinations. It was found in May that one of the pins in the level frame of the Prin transit, for holding the frame in a vertical position, was slightly bent, causing the level frame to be inclined to the vertical in one position of the level. This had produced a small systematic error in the measured level constant, and a correction, $0^s.072$, has been applied to the clock corrections of the Prin transit determined before May 30, when the trouble was remedied.

The clamp difference of the six-inch remained practically constant, and a correction, $\pm 0^s.024$, has been applied to the clock corrections determined with this instrument, to reduce to the mean of the two clamps.

The following table gives a comparison of the clock corrections as determined with the two instruments for each month, from November, 1922, to July, 1923, inclusive. The differences are in the sense Prin minus the six-inch.

Month	Difference in Clock Corrections	No. of Nights.	Month	Difference in Clock Corrections	No. of Nights.
1922			1923		
Nov.	$+0^s.001$	10	March	$-0^s.002$	12
Dec.	$+0.005$	9	April	$+0.010$	11
1923			May	-0.007	12
Jan.	$+0.006$	11	June	-0.026	8
Feb.	-0.015	8	July	-0.001	9

These differences are too small to explain the fluctuations which appear in radio time comparisons. That such fluctuations occurred during the course of these observations is evident from the following table giving a comparison between the Washington and Paris time determinations by means of the Bordeaux rhythmic wireless time signals. These signals were received and recorded automatically during the winter months by the time service of the Naval Observatory. The definitive Paris times of the Bordeaux signals were obtained from the *Bulletin Horaire du B. I. H.* The sign (+) means that the Washington recorded times are later than the Paris times.

Month	Washington — Paris	No. of Days	Month	Washington — Paris	No. of Days
1922			1923		
Nov.	$+0^s.11$	9	January	$+0^s.04$	19
Dec.	$+0.09$	15	February	-0.04	19
			March	-0.11	16

If the above variation is due in part to errors in the time determinations at the Naval Observatory, it is evident that such errors arise from local conditions which affect the observations of the six-inch and Prin instruments alike.

OBSERVATIONS OF THE ECLIPSES OF SATELLITES OF *JUPITER*, 1922,

MADE WITH THE 26-INCH AND 12-INCH REFRACTORS OF THE U. S. NAVAL OBSERVATORY,

By ASAPH HALL and ERNEST CLARE BOWER

[Communicated by CAPT. W. D. MACDOUGALL, U. S. Navy, Superintendent of U. S. Naval Observatory.]

G. M. T.		Ph.	Seeing	Inst.	Power	Obs.	Remarks
							Satellite I
1922	h m s						
Jan. 5	22 28 16	D	f	26	183	H.	Clouds. Haze.
14	18 50 5	D	vp	26	183	H.	Early.
14	18 49 55	D	vp	12	115	B	Probably visible 1s later.
30	17 1 6	D	vp	26	183	H.	
30	17 3 53	D	vp	12	85	B	Late 3s. Considerable haze.
Feb. 22	17 11 1	D	vp	26	183	H.	
Mar. 8	20 57 21	D	f	26	183	H.	
8	20 57 28	D	f	12	115	B	Late 3s ± 1s. Haze.
Apr. 18	15 59 1	R	f	26	183	H.	Late.
18	15 59 5	R	p	12	85	B	Considerable haze. Observation worthless.
May 11	16 10 7	R	p	26	183	H.	Late. Clouds. Haze.
Jun. 3	16 22 30	R	f	26	183	H.	Saw momentarily 2s before given time, then went out.
							Satellite II
1922							
Jan. 12	19 30 26	D	vp	26	183	H.	Eyepiece fogged.
12	19 30 30	D	p	12	115	B	Late 2s. Some haze.

Ph.: D = disappearance of last speck of light, R = reappearance of first speck of light.

*U. S. Naval Observatory, Washington, D. C.,
1923, July 19.*

OCCULTATION OF *VENUS*,

By J. G. PORTER.

The following observations of the occultation of *Venus* on the morning of Jan. 13 were made at the Cincinnati Observatory. E. I. YOWELL observed with the 16-inch equatorial and J. G. PORTER with the 4-inch equatorial. The phases are given in 90th meridian time.

	YOWELL	PORTER
Immersion, south cusp	$5^h 17^m 06^s.8$	5 17 05.0
Immersion, north cusp	18 01 .3	
Immersion, limb	18 21 .0	18 23.5
Emersion, north cusp	6 18 49 .0	6 18 48.0
Emersion, south cusp	19 56 .1	
Emersion, limb	20 13 .0	

*The Cincinnati Observatory,
Feb. 21, 1923.*

OBSERVATIONS OF THE SATELLITE OF *NEPTUNE*, 1921-23,

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

BY ASAPH HALL AND ERNEST CLARE BOWER.

[Communicated by CAPTAIN W. D. MACDOUGALL, U. S. Navy, Superintendent of U. S. Naval Observatory.]

Date		G. M. T.	p	G. M. T.	s	Comp.	Seeing	Power	Obs.	Remarks
		h m s	°	h m s	″					
1921 Dec.	19	19 18 31	314.54	19 20 16	16.43	1, 1	p	195	B	Faint. Haze.
1922 Jan.	30	16 15 27	284.00	16 17 15	13.82	1, 5	f	195	B	
Mar.	17	14 15 50	323.37	14 17 17	16.62	1, 1	f p	195	H	
	23	13 50 29	319.76	13 44 33	16.01	1, 1	g	195	H	Faint at last. Haze.
Apr.	20	14 35 3	57.80	14 36 52	10.08	1, 1	f p	195	H	
	22	14 25 18	295.01	14 27 49	15.77	1, 1	f	195	B	
1923 Feb.	21	15 2 58	316.75	15 8 4	16.92	1, 1	f	195	H	Faint. Haze.
Mar.	5	14 14 10	309.00	14 14 5	16.75	1, 1	p g	195	H	
	10	17 20 47	310.68	17 17 24	14.34	1, 1	p f	195	H	
	14	14 0 7	124.73	13 59 36	16.37	1, 1	f	195	H	
	17	13 16 15	304.69	13 15 34	16.76	1, 1	f	195	H	
Apr.	6	13 59 57	144.95	13 58 39	15.92	1, 1	f g	195	H	Faint.
	9	13 18 2	324.13	13 16 55	16.57	1, 1	f	195	H	
	20	13 46 25	359.61	13 44 27	14.68	1, 1	f	195	H	
	24	13 53 25	309.34	13 54 23	16.34	1, 1	p	195	H	Windy.
May	3	13 39 26	303.94	13 44 18	16.45	1, 1	f g	195	H	Faint.
	6	13 57 5	124.20	13 57 5	15.80	1, 1	f g	195	H	
	19	13 59 58	32.48	14 4 4	9.24	1, 1	f g	195	H	Faint. Haze.

U. S. Naval Observatory, Washington, D. C.,
1923, Jul. 24.

DAYLIGHT OCCULTATION OF *ALDEBARAN*,

BY R. A. ROSSITER.

A daylight occultation of *Aldebaran* by the Moon was observed by R. A. ROSSITER, as follows:

Immersion: 1923 April 19 6 18 16.7 A. A. Sid. Time
10 5 17.5 G. M. T.

Emersion: 7 40 44.2 A. A. Sid. Time
11 27 31.5 G. M. T.

The observation was made with the 12-inch refractor.

The times of observation are correct to the nearest half second.

A clear sky and good seeing attended the observation, but a strong wind caused some vibration of the telescope tube.

Ann Arbor,
April 20, 1923.

CONTENTS

EDITOR, BENJAMIN BOSS, ALBANY, N. Y.; ASSOCIATE EDITORS, ERNEST W. BROWN, F. R. MOULTON AND R. S. WOODWARD. PUBLISHED BY THE DUDLEY OBSERVATORY, ALBANY, N. Y., U. S. A., TO WHICH ALL COMMUNICATIONS SHOULD BE ADDRESSED. PRICE $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS & SON CO., LYNN, MASS. *Closed, September 22, 1923.*

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FOUNDED BY B. A. GOULD.

No. 830

VOL. XXXV ALBANY, N. Y., 1923, OCTOBER 2 NO. 14

DECLINATIONS OF 336 STARS.

By SAMUEL G. BARTON.

The following declinations were obtained by measuring the difference of declination from the stars of Boss's *Preliminary General Catalogue*. The differences were measured with the micrometer of the zenith-telescope of the Flower Observatory, between October 1916 and July 1920. Observations were taken with the telescope in both East and West positions. All of the stars observed are contained in the *A. G. Bonn Catalogue*, so that the declinations are all between 10° and 50° North.

The columns give respectively the BONN number of the star observed, the Boss number of the comparison star, the magnitude of the star observed, its right ascension as given in the catalogue, the observed declination reduced to 1875 with the constants of the catalogue, the difference in declination, observed *minus* BONN, the mean epoch of the observations, the resulting proper-motion in declination and the number of observations. If the star is contained in the *Catalogue of Proper-Motion Stars*, Publications of the Cincinnati Observatory, No. 18, the fact is noted below the table. Some of the stars given in *Astronomical Journal*, No. 762, of which additional observations have been secured or errors of position noted, are repeated herein.

A.G. BONN	Boss	Mag.	R.A. 1875	Dec. 1875	Diff.	Ep. 1900+	μ'	n
			h m s	° ′ ″	″		″	
188	82	7.2	0 11 18	13 52 59.10	− 1.10	18.7	−.027	5
196	82	7.0	0 11 45	13 51 50.10	− 1.40	19.1	−.033	1
532	180	8.0	0 31 34	44 7 36.15	+ 2.37	16.9	+.053	1
595	180	5.8	0 39 16	44 10 38.95	− 2.15	16.8	−.065	6
701	180	7.6	0 45 39	44 27 12.95	− 1.15	19.3	−.029	5
713	180	7.7	0 48 25	44 24 50.22	− 1.68	18.7	−.045	5
760	246	8.3	0 49 51	13 30 6.01	− 0.59	18.1	−.017	1
1018	246	7.7	1 6 20	13 30 35.33	− 2.77	17.5	−.062	5
1066	304	7.7	1 9 58	44 56 9.57	− 1.03	18.7	−.025	5
1070	246	7.9	1 10 16	13 23 55.02	− 0.38	17.7	−.009	4
1095	304	8.0	1 11 32	45 0 30.71	+ 0.11	17.5	+.011	5
1098	304	7.9	1 11 44	45 2 48.98	+ 1.68	18.4	+.038	4
1117	246	8.4	1 12 52	13 17 12.25	− 0.65	17.7	−.015	5
1185	304	8.5	1 18 1	44 57 1.54	− 0.66	20.0	−.014	4
1212	304	8.1	1 19 26	45 1 35.75	− 0.15	18.4	−.010	1
1246	304	7.7	1 21 16	44 59 6.24	+ 0.24	17.6	+.006	1
1303	420	7.5	1 26 15	10 15 31.76	− 1.84	17.7	−.047	4
1385	304	8.1	1 30 51	45 1 34.98	− 1.92	16.9	−.060	5
1388	420	8.3	1 30 57	10 17 12.20	− 1.10	18.7	−.042	1
1412	420	7.1	1 32 13	10 2 55.36	− 2.74	17.7	−.074	4
1438	304	8.0	1 34 21	44 56 38.59	+ 0.09	17.6	+.003	4
1464	420	8.4	1 36 1	10 20 37.85	− 1.15	18.5	−.027	4
1497	120	8.0	1 38 53	10 21 23.54	− 2.06	16.9	−.057	5
1533	120	8.5	1 41 11	10 20 11.78	− 0.52	18.0	−.013	3
1613	120	7.4	1 47 8	10 2 23.48	− 0.52	18.8	−.015	1
1618	120	6.9	1 47 23	10 5 15.27	− 3.33	17.9	−.090	6
1665	120	7.8	1 50 24	10 20 20.03	− 1.57	17.5	−.034	2
1681	120	8.3	1 50 50	10 18 10.40	− 1.00	18.0	−.023	5
1788	529	8.4	1 58 27	46 27 1.85	− 0.07	16.9	−.001	6
1796	529	8.5	1 59 1	46 37 58.72	+ 0.52	18.4	+.012	4
1895	529	6.5	2 6 2	46 53 54.87	− 1.33	18.4	−.035	1
1895	522	6.5	2 6 2	46 53 55.12	− 1.08	18.4	−.028	4
2101	619	8.1	2 21 50	13 35 45.75	+ 1.65	18.9	+.037	4
2122	619	8.3	2 23 38	13 55 56.15	+ 0.25	16.9	+.006	6
2143	619	8.3	2 25 2	13 51 18.26	− 1.01	18.0	−.023	4
2225	619	8.3	2 30 31	11 1 6.62	+ 0.32	17.7	+.007	1
2251	619	7.4	2 32 31	13 33 5.49	− 0.99	17.5	−.022	5
2384	619	8.3	2 39 45	13 40 51.01	− 1.39	18.1	−.034	6
2398	672	7.5	2 40 48	16 41 11.76	− 3.14	17.8	−.073	4
2491	672	6.9	2 48 7	16 39 19.56	− 1.04	16.9	−.028	5
2586	740	8.4	2 55 16	13 37 13.89	− 0.51	18.5	−.014	4
2622	672	7.0	2 59 11	46 49 26.38	− 0.02	16.9	−.000	4
2680	740	8.2	3 1 8	43 23 13.07	− 1.53	19.2	−.036	5
2685	740	8.2	3 1 33	43 18 53.67	− 1.33	17.9	−.030	4
2700	740	7.6	3 5 29	43 23 37.20	− 3.40	19.5	−.081	4
2779	805	7.9	3 11 48	45 25 2.81	− 1.06	16.9	−.025	4

A.G. Bonn	Boss	Mag.	R.A. 1875	Dec. 1875		Diff.	Ep. 1900 +	μ'	n
			h m s	° ′ ″		″		″	
[illegible]	[illegible]	8.[illegible]	3 29 20	15 1 38.59		1.11	19.7	−.031	5
[illegible]	86[illegible]	8.0	3 32 51	15 29 19.15	+	0.35	17.5	+.009	2
[illegible]	87[illegible]	8.0	3 32 31	15 29 19.86	+	0.76	17.9	+.019	2
[illegible]	862	8.7	3 32 40	15 15 36.91	−	6.66	17.8	−.166	1
[illegible]	[illegible]	8.[illegible]	3 33 37	15 1 58.68		1.22	19.6	−.029	1
[illegible]25	867	[illegible]	3 35 50	15 12 6.63	−	0.87	17.8	−.022	1
[illegible]47	880	8.[illegible]	3 37 44	18 21 29.63	−	0.37	17.0	.009	1
[illegible]	853	8.[illegible]	3 42 53	15 1 21.61	+	0.14	19.7	+.003	5
[illegible]	853	8.2	3 45 44	15 8 15.39		0.41	19.3	−.009	1
[illegible]287	889	8.0	3 50 45	18 24 1.83	+	0.13	16.9	+.010	7
[illegible]	88[illegible]	7.8	3 51 44	18 29 23.58		1.12	16.9	−.027	1
[illegible]	900	8.0	3 59 44	19 32 54.69		4.21	18.7	−.113	1
3401	900	7.4	3 59 29	19 51 18.95	−	0.95	17.4	−.025	6
3579	900	7.2	4 12 23	19 13 59.06	+	0.16	17.7	+.001	8
3615	1060	8.2	4 18 3	12 37 33.18	−	7.52	19.4	−.187	4
3627	1064	7.4	4 18 57	12 51 21.23		0.98	19.1	−.020	3
3695	1102	7.[illegible]	4 25 18	19 51 30.25		0.65	16.9	−.046	4
3715	1060	7.9	4 27 44	12 31 31.44	−	2.26	18.0	−.049	3
3729	1060	8.0	4 28 39	12 15 47.80		1.60	20.1	−.038	2
3729	1064	8.0	4 28 39	12 15 47.93		1.47	19.1	−.035	2
3744	1060	8.0	4 29 37	12 42 19.01	−	0.19	18.8	−.005	5
3851	1102	8.4	4 39 23	19 51 18.32	−	1.38	16.9	−.035	4
4058	1230	8.0	4 53 32	16 28 30.00	−	1.40	17.4	.031	3
4219	1222	8.5	5 3 51	16 11 58.96	−	4.44	20.1	.108	3
4219	1230	8.5	5 3 51	16 11 59.03	−	4.07	20.1	−.107	3
4252	1222	7.9	5 4 31	16 19 21.50	+	0.40	18.8	+.010	3
4252	1230	7.9	5 4 31	16 19 25.14	+	1.04	18.8	+.027	3
4351	1222	7.7	5 14 20	16 49 51.33	−	0.87	19.3	−.020	5
4351	1230	7.7	5 14 20	16 49 52.14	−	0.07	18.9	−.002	5
4371	1230	8.7	5 12 17	16 34 40.01		1.59	19.1	−.040	4
4388	1222	8.4	5 13 13	16 51 46.23		4.37	19.1	.106	4
4388	1230	8.4	5 13 43	16 51 46.79	−	3.81	19.1	.093	4
4422	1222	8.3	5 15 53	16 49 8.99	−	2.31	18.8	−.053	3
4422	1230	8.[illegible]	5 15 53	16 49 9.58		1.72	19.2	−.039	2
4432	1222	8.2	5 16 55	16 42 11.99	−	1.91	20.4	−.047	3
4432	1230	8.2	5 16 55	16 42 12.27		1.63	20.4	.040	3
4550	1444	7.4	5 25 46	19 30 34.99		1.14	17.4	.030	3
4700	1487	7.9	5 36 56	17 50 51.00	+	0.50	19.1	+.013	4
4738	1487	8.8	5 40 4	17 18 2.79		1.11	19.1	.032	4
4830	1487	8.2	5 46 56	17 11 28.05		1.25	19.6	−.028	4
4857	1500	8.2	5 49 4	13 11 4.38		0.92	17.1	−.021	4
4895	1500	8.4	5 51 13	13 10 6.63		0.47	17.6	−.011	6
4927	1487	7.5	5 53 10	17 18 1.81	+	4.04	20.1	+.095	4
[illegible]	1487	7.4	5 53 39	17 59 5.46	−	3.31	19.6	−.076	5
[illegible]	1500	7.3	6 0 39	13 9 23.51		0.19	17.1	−.011	6
[illegible]	1500	7.4	6 2 29	13 11 8.62	+	0.22	17.2	+.005	6
517[illegible]	1606	8.4	6 11 33	19 21 14.91	+	0.84	18.4	+.019	6
508[illegible]	[illegible]	8.4	6 1 4	19 29 3.10		0.00	17.6	.006	4
[illegible]122	1606	7.4	6 7 44	19 31 26.18	+	0.28	17.6	+.007	5
[illegible]138	1606	8.2	6 8 49	19 43 13.11		3.26	19.0	.078	5

A.G. Bonn	Boss	Mag.	R.A. 1875	Dec. 1875		Diff.	Ep. 1900 +	μ'	n
			h m s	° ′ ″		″		″	
5173	1606	8.4	6 11 33	19 21 14.91	+	0.84	18.4	+.019	6
5352	1724	7.1	6 26 52	13 48 3.99	+	0.09	17.2	+.002	4
5354	1694	8.0	6 27 3	12 12 35.60	−	1.90	19.2	−.040	4
5555	1724	8.7	6 42 50	13 48 43.38	−	2.02	18.0	−.044	5
5567	1694	8.1	6 43 40	12 45 52.18	+	0.58	18.5	+.013	5
5584	1779	7.5	6 44 43	16 21 59.96	−	1.44	19.0	+.031	5
5683	1860	8.5	6 52 37	17 16 51.85	+	0.25	17.1	+.006	4
5711	1860	7.7	6 54 12	17 13 10.75	+	0.95	17.2	+.023	7
5730	1860	8.5	6 56 17	17 45 24.79	−	3.01	18.0	−.072	5
5901	1980	8.2	7 12 46	16 27 26.00	−	2.10	19.5	−.047	3
5978	1980	7.5	7 19 5	16 14 19.83	−	1.27	19.0	−.031	5
6065	1949	8.0	7 26 12	11 8 42.42	+	0.82	19.5	+.018	3
6089	1949	7.8	7 28 14	11 7 14.25	+	1.65	19.2	+.036	4
6092	1949	8.2	7 28 15	11 3 35.21	+	1.11	18.2	+.025	4
6195	1980	8.3	7 37 39	16 23 35.47	−	2.73	18.4	−.082	6
6215	2079	8.2	7 39 21	18 1 30.78	−	9.02	18.0	−.236	5
6312	2148	8.3	7 49 36	12 59 5.18	−	1.92	18.2	−.057	4
6315	2142	7.7	7 49 51	13 50 12.96	+	0.96	17.4	+.024	4
6324	2079	8.5	7 50 52	18 7 19.46	−	2.00	17.7	−.046	4
6436	2142	8.4	8 2 56	13 46 28.20	+	0.50	18.2	+.014	4
6450	2142	8.2	8 4 32	13 22 20.00	−	1.86	17.2	−.040	4
6466	2142	7.4	8 6 13	13 24 10.07	−	0.73	17.2	−.017	5
6499	2142	7.4	8 9 17	13 17 33.67	+	0.87	17.2	+.024	4
6648	2220	7.7	8 24 18	12 33 36.86	−	0.81	17.2	−.026	4
6668	2333	8.6	8 27 8	12 10 53.47	−	29.13	18.6	−.645	5
6683	2333	8.5	8 28 44	12 13 40.48	+	0.08	18.7	+.002	4
6691	2333	8.6	8 29 48	12 44 5.08	−	3.42	18.7	−.079	4
6747	2392	8.0	8 35 20	15 54 1.76	−	0.74	18.2	−.018	4
6836	2392	8.4	8 47 6	16 8 8.58	−	0.22	19.2	−.005	6
6912	2465	7.7	8 56 40	13 56 6.13	−	1.07	17.3	−.026	4
6916	2465	7.9	8 56 35	13 57 4.77	−	2.63	17.7	−.063	4
6957	2333	8.4	9 0 40	15 53 59.95	−	0.05	18.7	−.001	4
6965	2484	8.2	9 1 26	17 30 54.87	−	1.23	17.2	−.028	4
6995	2484	7.9	9 5 12	17 30 8.84	+	0.74	17.2	+.019	4
7014	2531	8.4	9 7 44	15 57 20.96	−	1.34	18.2	−.052	5
7030	2465	8.2	9 8 55	13 36 15.85	+	0.75	18.2	+.016	5
7065	2531	7.4	9 13 8	15 53 53.25		1.65	17.2	−.039	4
7088	2531	8.3	9 16 7	16 44 18.52	−	1.98	18.9	−.043	6
7089	2465	7.9	9 16 13	13 30 19.34	−	1.36	18.2	−.034	5
7183	2604	8.1	9 27 27	10 32 39.65	+	0.65	17.8	+.015	5
7185	2604	7.3	9 27 33	10 31 4.24	+	0.84	18.6	+.022	5
7186	2604	8.3	9 27 34	10 30 43.04	+	1.44	18.0	+.047	5
7201	2626	8.3	9 29 44	16 27 51.44	−	3.69	18.2	−.082	5
7280	2626	8.0	9 37 58	16 26 37.75	+	0.65	18.2	+.014	5
7283	2604	8.5	9 38 24	10 26 12.50	+	0.60	17.8	+.015	5
7313	2665	8.3	9 41 48	14 38 44.96	−	3.66	18.2	−.076	4
7373	2626	8.5	9 49 19	16 29 18.98	−	1.12	18.6	−.106	5
7393	2665	8.4	9 52 0	14 43 39.78		1.02	17.9	−.024	3
7495	2773	7.7	10 3 57	12 20 17.64	−	1.66	18.2	−.037	4
7508	2744	8.1	10 5 54	12 30 2.74	+	0.64	20.2	+.014	4

A.G. Bonn	Boss	Mag.	R.A. 1875	Dec. 1875	Diff.	Ep. 1900 +	μ'	n
			h m s	° ' "			"	
7513	2744	8.2	10 6 19	42 25 55.30	+ 1.00	18.7	+.026	4
7544	2773	6.8	10 9 48	42 5 23.84	− 2.06	18.2	−.047	1
7590	2806	8.7	10 16 9	49 13 41.06	− 1.11	17.2	−.030	4
7628	2806	7.0	10 20 21	49 35 59.59	− 1.59	17.2	+.040	4
7646	2773	8.2	10 23 4	42 6 54.05	− 1.75	18.2	−.037	4
7662	2744	8.5	10 25 53	42 22 35.14	+ 0.11	19.0	+.003	5
7689	2806	8.6	10 29 44	49 47 15.13	+ 0.13	18.0	+.010	1
7700	2806	8.4	10 31 4	49 51 22.64	− 0.66	19.1	−.015	5
7725	2912	8.0	10 35 45	42 32 53.92	+ 0.72	18.3	+.015	5
7793	2920	7.1	10 45 36	40 50 7.48	− 3.02	17.2	−.067	6
7867	2912	8.0	10 54 35	42 31 52.16	− 0.21	18.2	−.005	5
7881	2920	8.0	10 56 4	44 10 35.19	− 0.31	19.0	−.006	5
7934	2920	8.4	11 5 39	44 12 48.00	+ 0.40	19.5	+.008	4
7943	2995	7.8	11 7 17	44 0 43.81	− 1.99	17.1	−.109	4
7965	2995	8.6	11 9 52	43 57 31.67	− 1.73	18.9	−.017	3
8015	3028	8.6	11 16 51	43 48 28.17	− 3.53	19.2	−.079	4
8022	3028	8.5	11 18 16	43 51 6.92	+ 0.92	18.9	+.018	3
8095	3083	8.5	11 25 54	42 27 53.76	− 2.04	18.8	−.042	4
8109	3085	8.4	11 28 28	42 19 40.85	− 0.55	19.6	−.014	3
8219	3143	8.4	11 44 57	43 37 33.61	+ 0.01	19.1	+.000	5
8243	3143	7.9	11 47 7	43 36 41.79	− 1.91	18.6	−.040	6
8349	3143	7.1	12 1 0	43 47 36.16	− 0.03	19.8	−.001	4
8467	3193	7.7	12 15 38	44 21 10.60	− 0.30	18.9	−.006	5
8483	3193	8.0	12 17 43	44 21 44.00	− 1.80	19.5	−.036	5
8532	3297	8.3	12 24 45	44 31 46.04	− 1.50	19.3	−.032	5
8557	3297	8.1	12 27 22	44 25 2.98	− 1.32	19.5	−.027	5
8715	3297	8.3	12 47 45	44 34 10.94	− 1.79	18.7	−.037	2
8777	3396	7.5	12 57 5	46 3 26.27	+ 0.77	18.3	+.017	4
9044	3500	7.3	13 32 16	42 50 17.70	− 0.10	19.3	−.002	5
9044	3568	7.3	13 32 16	42 50 16.92	− 0.88	20.3	−.018	3
9081	3500	8.5	13 36 42	42 50 40.00	− 3.70	19.0	−.075	4
9081	3568	8.5	13 36 42	42 50 39.27	− 4.43	20.3	−.088	3
9141	3500	7.5	13 45 37	42 46 28.55	+ 0.77	20.3	+.015	3
9141	3568	7.5	13 45 37	42 46 28.05	+ 0.25	20.0	+.005	5
9160	3500	6.8	13 48 8	42 48 3.44	+ 0.31	20.3	+.006	3
9160	3568	6.8	13 48 8	42 48 2.72	− 0.08	19.7	−.002	6
9205	3500	7.8	13 54 32	42 39 22.70	+ 2.10	20.4	+.043	2
9205	3568	7.8	13 54 32	42 39 22.06	+ 1.46	19.8	+.029	4
9224	3658	8.4	13 56 9	44 53 44.31	+ 0.94	18.7	+.019	3
9384	3733	8.5	14 15 20	49 52 20.89	+ 0.29	18.4	+.007	4
9404	3658	7.8	14 17 19	42 1 16.35	− 0.55	19.1	−.011	4
9422	3733	7.0	14 19 6	49 58 24.38	+ 0.18	18.2	+.005	5
9455	3733	7.2	14 23 46	49 57 23.49	+ 1.09	18.2	+.027	7
9523	3764	7.6	14 34 16	40 17 54.33	− 0.47	19.2	−.016	5
9609	3789	8.6	14 41 7	46 27 50.89	− 0.04	18.9	.000	4
9658	3789	8.9	14 48 28	46 39 58.17	+ 0.07	18.9	+.002	4
9703	3853	7.5	14 52 56	48 53 42.21	+ 4.64	18.4	+.112	5
9709	3789	8.2	14 53 24	46 45 9.14	− 1.26	18.1	−.032	3
9804	3922	8.2	15 3 34	40 8 50.60	− 1.90	19.2	−.039	4
9840	3922	8.6	15 7 36	40 7 15.50	− 7.00	19.2	−.156	4
9857	3853	7.2	15 9 53	48 26 6.69	− 0.61	18.2	.011	1
9886	3922	8.1	15 13 59	40 3 57.30	− 2.01	19.0	−.012	5
9985	3979	7.6	15 25 36	40 18 16.52	+ 1.82	18.7	+.045	1
10051	3979	8.2	15 31 32	40 11 12.28	− 3.32	19.4	−.077	5
10125	4056	8.3	15 39 53	43 6 49.02	− 0.08	19.2	−.002	4
10136	3979	7.6	15 41 7	40 34 5.85	− 1.57	18.7	−.037	4
10189	4056	8.6	15 47 30	43 7 20.81	+ 1.74	19.4	+.040	3
10273	4056	8.6	15 57 9	43 5 25.05	1.47	18.1	−.039	3
10403	4124	8.1	16 8 40	43 58 7.88	− 0.92	18.5	−.029	1
10467	4209	6.8	16 15 42	49 20 18.60	+ 1.06	19.9	+.025	1
10479	4209	8.5	16 16 48	49 20 56.02	+ 3.02	20.1	+.076	3
10482	4124	7.3	16 17 13	44 6 57.22	2.18	18.5	.057	5
10501	4201	8.1	16 19 42	42 24 0.82	0.38	17.7	.007	1
10562	4209	8.1	16 25 29	49 15 0.01	− 0.50	19.7	−.012	5
10603	4228	8.5	16 29 53	46 18 48.25	+ 3.75	19.0	+.092	4
10656	4209	7.4	16 35 8	49 6 35.47	− 0.53	19.5	−.012	1
10670	4201	8.1	16 36 41	42 23 17.63	− 1.87	17.0	−.018	5
10693	4305	8.1	16 39 31	42 50 56.04	+ 1.84	19.0	+.044	1
10804	4349	7.2	16 49 47	43 59 21.79	− 2.81	18.2	−.070	1
10845	4349	7.2	16 53 31	43 52 37.49	− 0.11	17.9	−.005	5
10886	4349	8.5	16 56 25	43 56 22.73	− 0.87	19.2	−.018	4
11011	4408	8.7	17 7 15	46 9 50.17	− 3.33	19.0	.078	1
11050	4408	8.4	17 11 37	46 8 27.06	− 2.21	18.9	−.050	5
11094	4349	8.2	17 14 54	43 14 21.67	− 1.53	17.0	−.038	2
11208	4408	8.0	17 21 44	46 9 56.97	− 0.25	19.5	.006	1
11209	4484	6.8	17 21 52	44 29 58.71	− 0.20	17.9	−.005	4
11216	4408	8.2	17 26 0	46 27 1.41	+ 3.21	17.5	+.081	1
11308	4514	7.9	17 33 16	48 32 11.41	− 6.50	20.0	−.149	1
11342	4514	7.8	17 35 52	48 30 36.61	− 2.19	19.1	−.0[illegible]7	1
11489	4514	8.4	17 47 31	48 25 19.02	+ 1.12	18.6	+.031	5
11489	4572	8.4	17 47 31	48 25 18.82	+ 0.92	18.6	+.026	5
11579	4514	7.3	17 51 14	48 18 28.77	+ 0.37	18.5	+.008	3
11579	4572	7.3	17 51 14	48 18 28.62	+ 0.22	18.4	+.005	5
11618	4544	8.0	17 57 26	48 24 15.90	− 0.10	18.6	−.002	2
11618	4572	8.0	17 57 26	48 24 15.13	− 0.57	18.2	−.014	5
11763	4514	7.3	18 6 38	48 22 30.54	+ 3.84	18.6	+.109	2
11763	4572	7.3	18 6 38	48 22 30.09	+ 3.39	17.9	+.098	6
11786	4572	7.3	18 8 18	48 15 37.82	− 1.18	17.6	−.029	4
11848	4872	6.7	18 13 8	48 19 25.15	− 0.05	17.5	−.001	1
11857	4653	7.7	18 13 42	49 2 51.81	+ 0.61	18.9	+.014	6
12067	4741	8.0	18 27 53	44 55 39.27	− 13.83	18.6	−.387	6
12287	4805	8.1	18 41 42	44 16 21.03	+ 0.03	18.6	+.001	1
12287	4870	8.1	18 41 42	44 16 23.82	− 0.18	18.4	.004	5
12290	4805	6.4	18 42 13	44 18 29.65	+ 0.15	19.7	+.003	1
12290	4870	6.4	18 42 13	44 18 29.68	+ 0.18	19.7	+.004	2
12360	4805	8.1	18 46 35	44 21 39.13	+ 0.33	19.0	+.007	3
12360	4870	8.1	18 46 35	44 21 39.19	+ 0.09	18.6	+.002	4
12380	4805	7.8	18 47 18	44 18 53.58	− 0.92	19.0	−.019	3
12380	4870	7.8	18 47 18	44 18 53.67	− 0.83	18.3	−.018	8
12384	4741	7.1	18 47 49	44 59 2.85	− 0.28	18.3	−.007	4

A.G. Bonn	Boss	Mag.	R.A. 1875	Dec. 1875	Diff.	Ep. 1900+	μ'	n
			h m s	° ' "	"		"	
12489	1870	6.7	18 48 7	11 43 55.79	+ 0.29	19.7	+.006	4
12526	1870	7.8	18 57 8	11 44 13.31	+ 0.91	18.4	+.023	5
12528	1807	7.4	18 57 39	11 48 36.22	+ 2.12	18.3	+.045	3
12711	1870	7.3	19 8 12	11 1 40.48	2.82	19.3	−.068	5
12753	1870	8.5	19 10 17	11 5 25.54	+ 1.64	19.7	+.035	2
12755	1870	8.4	19 10 22	11 2 38.32	− 0.78	19.7	−.016	2
12771	1870	8.4	19 11 29	11 22 25.84	− 0.66	18.4	−.015	4
12801	1870	7.5	19 13 3	11 2 26.74	− 0.26	19.7	−.007	6
12851	1966	8.0	19 15 15	19 59 54.85	− 1.37	18.8	−.032	5
12861	1870	7.7	19 15 28	11 2 25.22	− 1.78	19.7	−.041	5
12894	1966	7.7	19 17 16	50 6 16.74	+ 2.41	19.3	+.057	5
12937	1966	6.9	19 20 7	50 1 40.37	+ 0.17	19.3	+.004	6
13000	1966	8.4	19 23 29	49 53 28.60	+ 3.40	19.7	+.080	5
13099	1966	7.5	19 27 43	49 55 56.04	+ 1.64	19.0	+.044	8
13147	1966	8.8	19 28 44	49 54 26.98	+11.78	18.9	+.278	4
13193	1966	6.2	19 32 37	49 57 34.47	+ 2.07	18.8	+.051	6
13211	5070	8.3	19 33 14	40 48 28.39	− 0.51	19.7	−.012	4
13217	5070	8.3	19 33 32	40 43 52.62	− 1.68	19.7	−.034	3
13234	5070	7.7	19 34 54	40 20 26.27	− 3.23	19.7	−.067	5
13308	5070	6.8	19 38 42	40 25 30.40	− 1.74	19.0	−.039	4
13333	5070	8.5	19 40 1	40 19 34.15	− 4.85	19.7	−.098	3
13345	5070	6.7	19 40 34	40 24 55.82	− 2.08	18.0	−.048	4
13364	5070	7.8	19 41 33	40 15 2.70	− 1.10	19.7	−.025	5
13605	5070	8.5	19 53 40	40 15 33.76	− 2.44	19.7	−.054	4
13684	5203	8.1	19 57 49	45 7 12.74	+ 1.44	19.2	+.032	5
13715	5070	7.0	19 59 38	40 18 12.78	− 1.22	19.7	−.025	5
13807	5203	7.8	20 4 9	45 10 16.57	− 1.33	19.2	−.034	5
13857	5203	8.4	20 6 26	45 6 17.34	+ 1.24	19.1	+.028	4
13879	5205	6.9	20 7 22	39 57 24.39	+ 0.19	18.7	+.005	4
13883	5203	8.4	20 7 27	45 20 35.76	− 1.94	19.7	−.044	4
13934	5205	7.8	20 10 0	39 56 58.32	− 0.38	18.4	−.013	4
13939	5203	8.3	20 10 27	45 44 24.16	− 0.04	19.7	−.001	4
14083	5203	8.4	20 16 22	45 10 46.85	+ 2.55	19.3	.056	5
14155	5203	8.0	20 19 4	45 14 15.28	+ 0.88	19.2	.019	4
14204	5205	6.7	20 21 34	39 59 34.25	+ 0.05	18.7	.001	4
14209	5203	8.7	20 22 2	45 0 16.72	+ 0.32	19.2	.008	5
14237	5203	8.3	20 23 2	45 16 18.78	− 0.52	19.7	−.011	5
14274	5203	7.3	20 24 44	45 18 10.58	+ 0.58	19.7	.013	4
14300	5205	8.2	20 25 50	45 1 43.18	+ 1.38	19.2	.030	5
14320	5205	7.4	20 26 34	40 0 19.78	+ 0.18	17.6	.004	2
14443	5325	7.5	20 34 46	49 59 29.85	+ 0.85	19.2	.020	4
14567	5389	8.2	20 38 4	46 44 2.20	− 4.50	18.6	−.111	4
14574	5389	8.5	20 38 23	46 57 3.37	2.73	19.7	−.087	4
14712	5325	7.8	20 44 10	50 1 11.44	+ 0.84	19.3	.021	5
14817	5327	8.5	20 49 30	50 0 13.15	− 2.15	19.2	−.054	4
15077	5474	8.0	21 2 44	43 16 17.64	− 0.06	19.7	−.001	4
15099	5389	7.9	21 3 3	46 46 27.24	+ 0.51	19.7	.012	4
15101	5389	8.7	21 3 17	46 48 12.74	+ 0.21	18.9	.004	5
15107	5474	8.2	21 3 44	43 44 29.44	+ 1.61	18.6	.035	2
15113	5474	7.9	21 4 5	43 19 22.32	0.48	19.0	−.010	3
15115	5389	7.9	21 4 9	46 45 4.87	− 0.23	19.7	−.006	5
15123	5389	7.2	21 4 36	46 45 52.02	+ 0.62	19.2	.014	5
15213	5474	7.8	21 8 32	43 21 34.08	− 0.22	18.6	−.005	4
15225	5474	8.5	21 9 12	43 44 32.84	− 0.09	19.7	−.002	2
15328	5539	8.3	21 13 57	49 24 22.28	+ 0.48	19.0	.012	4
15343	5539	7.5	21 14 30	49 32 34.39	+ 0.19	19.7	.005	4
15440	5474	8.2	21 18 4	43 42 32.80	+ 0.30	19.3	.007	5
15499	5539	8.6	21 21 54	49 45 6.44	+ 1.34	18.6	.033	4
15505	5474	7.3	21 22 2	43 46 13.33	− 1.27	19.3	−.029	5
15575	5539	7.4	21 24 26	49 44 57.74	+ 1.74	17.4	.049	4
15773	5579	7.3	21 33 2	40 34 13.64	− 4.46	18.5	−.106	4
15796	5539	6.8	21 34 0	49 43 55.95	+ 0.45	19.2	.011	4
15797	5539	8.4	21 34 0	49 23 54.15	+ 1.45	18.6	+.038	4
15999	5579	7.8	21 44 5	40 38 21.73	+ 4.53	17.3	+.107	2
16044	5669	8.4	21 46 1	43 55 18.12	− 1.58	18.7	−.036	4
16117	5669	7.0	21 50 16	43 49 38.53	− 0.77	18.5	−.017	3
16128	5669	8.2	21 50 34	44 12 12.11	− 0.79	19.7	−.018	5
16194	5669	8.4	21 53 34	44 5 43.49	− 0.41	19.7	−.010	5
16223	5669	8.2	21 55 3	43 57 10.11	+ 1.11	18.7	+.025	6
16254	5669	8.3	21 56 18	44 4 48.35	− 1.45	19.7	−.033	4
16284	5737	7.7	21 57 36	42 12 41.24	+ 1.44	16.8	+.037	4
16386	5669	8.6	22 3 36	43 56 35.54	+ 3.34	19.2	+.073	4
16418	5669	8.1	22 4 49	43 39 42.72	+ 0.02	18.8	+.001	6
16432	5737	7.9	22 5 32	42 7 18.59	+ 0.39	19.9	+.010	3
16472	5669	8.3	22 7 45	44 9 15.49	− 3.51	19.7	−.076	4
16557	5737	8.0	22 12 26	42 9 24.16	+ 3.86	18.1	+.093	4
16624	5834	8.7	22 15 43	49 20 34.89	+ 0.59	17.7	+.017	3
16691	5737	8.7	22 19 23	42 12 52.67	+ 2.27	19.3	+.050	4
16716	5737	8.4	22 20 55	42 14 18.41	− 0.99	18.3	−.022	7
16903	5876	8.0	22 30 13	44 5 56.86	+ 0.66	17.9	+.013	3
16903	5903	8.0	22 30 13	44 5 57.99	+ 1.79	17.9	+.040	3
16935	5876	8.5	22 35 9	43 52 46.94	− 0.59	19.2	−.014	4
16953	5903	7.0	22 33 8	44 4 10.49	+ 1.79	17.9	+.050	3
17010	5876	8.2	22 36 7	43 47 38.44	+ 8.04	18.4	+.205	5
17011	5834	8.0	22 36 7	49 26 23.62	+ 0.72	17.9	+.018	6
17014	5834	8.6	22 36 12	49 34 1.56	+ 1.36	19.7	+.032	4
17033	5834	8.0	22 37 27	49 29 15.39	− 1.31	19.8	−.032	4
17047	5876	7.3	22 38 10	43 52 31.59	− 0.01	17.8	.000	6
17065	5834	8.5	22 39 4	49 24 24.56	+ 0.86	18.8	+.027	4
17095	5834	8.4	22 40 58	49 33 7.53	+ 0.83	19.8	+.019	4
17152	5834	8.4	22 44 33	49 21 15.22	+ 2.92	18.2	+.074	4
17283	5958	8.6	22 51 59	48 35 25.34	+ 1.24	19.7	+.029	3
17324	5876	8.0	22 54 4	43 57 39.69	− 1.54	17.4	−.037	6
17387	5993	7.8	22 57 30	48 9 27.62	− 0.88	17.0	−.026	4
17444	5958	8.3	22 59 4	48 39 19.54	+ 0.84	19.7	+.019	5
17449	5993	8.0	22 59 28	48 22 37.02	− 2.28	17.9	−.055	5
17450	5958	8.4	23 4 49	48 35 49.00	+ 0.40	19.7	+.010	3
17538	5958	7.7	23 6 18	48 32 4.34	− 0.06	19.8	−.001	3
17539	5958	8.1	23 6 25	48 33 40.06	− 0.74	19.7	−.017	4
17630	5958	8.5	23 11 58	48 33 23.03	+ 0.73	19.7	+.018	4
17654	5993	9.0	23 13 15	48 43 37.65	+ 1.55	19.2	+.037	3
17660	5958	8.6	23 13 23	48 32 59.04	− 1.26	19.7	−.035	4

A.G. Bonn	Boss	Mag.	R.A. 1875	Dec. 1875	Diff.	Ep. 1900+	μ'	n
			h m s	° ′ ″			″	
17691	5958	7.9	23 15 39	48 32 21.99	− 0.91	19.7	−.023	4
17699	5993	7.6	23 16 12	48 6 35.89	+ 1.29	16.8	+.039	3
17804	6075	7.7	23 21 45	49 40 11.22	− 0.28	19.3	−.008	3
17811	5993	8.8	23 22 14	48 21 11.21	− 0.49	18.9	−.011	2
17848	5993	6.5	23 24 10	48 26 39.21	+ 0.41	17.1	+.010	4
17905	6075	7.8	23 27 4	49 39 52.28	+ 1.98	19.1	+.017	1
17935	6075	7.1	23 29 19	49 37 15.12	+ 0.22	19.4	+.005	4
17958	6101	7.8	23 20 51	45 29 56.05	− 0.55	16.9	−.016	5
17981	6101	6.5	23 31 19	45 30 28.02	− 0.38	16.9	−.011	1
18044	6101	7.0	23 34 59	45 31 34.00	− 1.60	16.8	−.047	5
18163	6075	8.3	23 11 52	49 36 30.04	+ 0.14	19.9	+.003	4

NOTES

A. G.	= Ci.	A. G.	= Ci.
3615	584	12067	2131
4249	670	13117	2553
6668	1000	17010	2954
6916	1071	17152	2982
7283	1157	17981	3099
11308	2349	7373	Double Σ1394

Flower Observatory, University of Pennsylvania, Upper Darby, Pa., August 3, 1923.

OBSERVATIONS OF THE SATELLITES OF *MARS*, 1911-22,

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

By ASAPH HALL and H. E. BURTON.

[Communicated by CAPTAIN W. D. MACDOUGALL, U. S. Navy, Superintendent of U. S. Naval Observatory.]

Date		G. M. T.	$\Delta\alpha$	G. M. T.	$\Delta\delta$	Comp.	Seeing	Power and Illum.	Obs.	Remarks
			Phobos – Mars							
		h m s	″	h m s	″					
1911	2	18 27 42	− 21.48	18 13 8	−1.10	4, 4	f	360r, Blk	Hl	Very faint.
Nov.	2	18 33 46	− 24.15	18 50 1	−1.60	4, 1	f	360r, Blk	Hl	
	10			14 27 23	+2.18	0, 4	f-p	388s, Blk	Bn	Very faint. Too faint to finish.
	16	15 8 38	+ 25.06	14 59 8	+0.18	4, 4	g	388s, Blk	Hl	
	16	15 12 25	+ 25.20	15 20 15	+1.39	1, 1	g	388s, Blk	Hl	
	16			15 25 1	+1.21	0, 4	f	388s, Blk	Hl	Became too faint.
	16	18 24 50	− 23.46	18 39 7	+0.26	1, 4	f	388s, Blk	Hl	Not difficult.
	16	18 55 53	− 25.63	18 44 9	+0.38	4, 4	f	388s, Blk	Hl	
	19	15 35 4	− 25.34	15 48 38	−0.07	4, 4	f	388s, Blk	Hl	
	19	16 15 12	− 23.62	16 0 22	−1.07	4, 4	f	388s, Blk	Hl	
	21	16 51 44	+ 21.65	17 1 5	−1.33	1, 1	f-g	388s, Blk	Hl	
	21	17 14 33	+ 24.51	17 5 5	−1.20	1, 1	f g	388s, Blk	Hl	
	21	17 32 35	+ 25.18	17 48 34	+1.22	1, 1	f g	388s, Blk	Hl	
	21	18 6 12	+ 21.63	17 53 55	+1.23	1, 1	f g	388s, Blk	Hl	
	22	15 33 38	+ 18.21	15 15 48	−2.04	1, 1	g	388s, Blk	Hl	Haze.
	22	16 6 9	+ 21.03	15 51 36	−1.57	1, 1	g	388s, Blk	Hl	Haze.
	25	14 7 41	+ 19.05	13 50 01	+2.00	4, 4	f	388s, Blk	Hl	Too poor to finish.
	25			17 17 59	−0.93	0, 1	g	388s, Blk	Hl	Stopped by haze.
	26	15 51 13	− 24.14	15 26 17	+1.95	4, 1	f	388s, Blk	Hl	
	26	15 57 56	− 21.64	16 9 52	−0.61	1, 1	f	388s, Blk	Hl	
Dec.	5	14 19 55	− 23.71	14 33 26	−1.30	4, 1	g	388s, Blk	Hl	
	5	14 53 17	− 21.76	14 40 29	−1.66	4, 1	g	388s, Blk	Hl	
	5	15 8 20	− 19.27	15 27 32	−1.24	4, 3	f g	388s, Blk	Hl	
	7	16 45 2	+ 19.75	16 55 33	+1.28	1, 1	g	388s, Blk	Hl	Moonlight. Haze.

Date		G. M. T.	Δa	G. M. T.	Δd	Comp.	Seeing	Power and Illum.	Obs.	Remarks
				Phobos	*Mars (Continued)*					
1911		h m s		h m s	″					
Dec.	7	17 11 30	+ 14.07	17 1 57	+ 1.67	2, 1	g	388s, Blk	Hl	Too close to planet to finish.
	10	17 18 15	− 20.95	17 30 14	− 3.14	1, 2	g	388s, Blk	Hl	Satellite went out.
	19	15 9 55	21.62		. . .	1, 0	f g	388s, Blk	Hl	Faint.
1913										
Dec.	20	17 27 50	+ 20.12	17 36 33	+ 0.12	4, 1	g	360r, Blk	Bn	
	20	17 53 25	+ 19.93	17 46 37	− 0.22	1, 4	g	360r, Blk	Bn	
	20	18 3 10	+ 19.13	18 12 34	− 1.68	4, 4	g	360r, Blk	Bn	
	20		. . .	18 20 31	− 1.59	0, 4	g	360r, Blk	Bn	Close to planet. Fog.
	27	14 22 14	− 20.38	14 30 46	+ 0.80	4, 1	f g	360r, Blk	Bn	
	27	14 49 30	17.24	14 38 14	+ 1.14	1, 4	f g	360r, Blk	Bn	
	27	18 19 30	+ 20.00	18 31 35	− 1.10	1, 4	g	360r, Blk	Bn	Haze.
	29	16 3 13	+ 20.55	16 9 54	− 0.79	4, 4	g	360r, Blk	Bn	
	29	16 26 31	+ 18.26	16 16 39	− 1.00	4, 4	g	360r, Blk	Bn	
	29	16 42 23	+ 15.77	16 51 34	− 1.77	4, 4	g	360r, Blk	Bn	Too close to planet to finish.
	29	19 54 9	− 20.83	20 0 20	+ 0.19	4, 4	g	360r, Blk	Bn	
	29	20 20 14	− 18.19	20 12 7	+ 0.79	4, 4	g	360r, Blk	Bn	
1914										
Jan.	5	16 4 0	+ 20.71	16 6 43	+ 0.13	1, 4	p	360r, Blk	Bn	
	5			16 26 55	− 1.09	0, 4	p	360r, Blk	Bn	Too poor to finish.
	6	15 26 43	+ 19.89	15 32 27	− 0.94	4, 4	f-g	360r, Blk	Bn	
	6			15 39 36	− 0.80	0, 4	f-g	360r, Blk	Bn	Stopped by haze.
	15	17 14 52	− 19.65	17 24 36	+ 0.30	4, 4	f	360r, Blk	Bn	Very faint.
1922			$\cos\delta\Delta a$		$\Delta\delta$					
May	29	19 31 39	+ 23.06	19 48 18	− 12.56	4, 4	f	360r, Blk	Hl	
	29	20 46 18	+ 18.86	19 56 49	− 12.38	4, 1	f	360r, Blk	Hl	
	30	17 19 25	+ 19.06	18 7 56	− 11.85	1, 4	f	360r, Blk	Hl	Clouds. Haze.
	30		. . . .	18 23 24	− 16.37	0, 4	f	360r, Blk	Hl	
			p		s					
			°							
Jun.	3	18 15 44	300.24	18 19 42	25.57	2, 2	f	360r, Blk	Hl	Satellite went out.
	7	17 56 56	120.01	18 24 0	24.23	2, 2	f	360r, Blk	Hl	Satellite went out. Haze. Clouds.
	12	16 39 33	301.99	16 44 57	27.94	4, 4	p	360r, Blk	Hl	
	15	16 41 18	119.75	17 19 14	27.03	2, 3	f	360r, Blk	Hl	Faint. Foggy. Stopped by clouds.
Jul.	6	14 23 0	301.61	14 52 56	26.86	2, 1	f	360r, Blk	Hl	Very faint. Haze. Moonlight. Too close to planet to finish.
				Deimos	*Mars*					
1911			Δa		Δd					
			″							
Nov.	3	17 14 14	+ 61.06	16 48 58	− 0.14	3, 4	f	388s, Blk	Hl	Very faint.
	10	15 25 14	62.69	15 3 2	− 0.42	1, 1	p f	388s, Blk	Hl	Very faint. Objectglass fogged
	10	15 37 15	− 63.29	15 58 54	− 0.53	1, 1	p f	388s, Blk	Hl	Red wires in Δa. Red wires in Δa.
	16	19 10 39	− 18.02	19 29 7	+ 3.86	1, 1	f	388s, Blk	Hl	Very faint.
	16	19 51 18	53.14	19 35 10	+ 3.78	5, 5	f	388s, Blk	Hl	Finally went out.
	19	14 37 16	− 17.66	14 18 3	− 1.76	1, 1	f	360r, Blk	Hl	Very faint. Rough observation.

Date	G. M. T.	$\Delta\alpha$	G. M. T.	$\Delta\delta$	Comp.	Seeing	Power and Illum.	Obs.	Remarks
1911				*Deimos*	*Mars (Continued)*				
	h m s	″	h m s	″					
Nov. 19	11 52 15	− 16.21	15 9 17	−5.11	1, 1	f	360r, Blk	Hl	Very faint. Rough observation.
21	19 13 9	− 38.15	19 31 11	+5.19	1, 1	f g	360r, Blk	Hl	Very faint. Rough observation.
21	20 0 17	− 15.81	19 47 2	+5.13	1, 1	f g	360r, Blk	Hl	Very faint. Rough observation.
22	11 5 50	+ 62.31	11 21 11	−0.58	1, 1	g	388s, Red	Hl	
22	11 46 34	+ 62.96	11 32 8	−0.10	4, 4	g	388s, Red	Hl	
26	14 8 56	+ 36.37			1, 0	p f	388s, Blk	Hl	Too faint to finish.
Dec. 6	13 28 50	+ 55.23	13 5 1	+3.05	1, 1	g	388s, Red	Hl	Very faint. Bright moonlight.
6	13 38 27	+ 51.33	13 56 11	+1.51	1, 1	g	388s, Red	Hl	Haze.
7	17 27 11	+ 58.01	17 10 27	−0.08	1, 1	g	388s, Red	Hl	Very faint.
7	18 1 57	+ 58.63	17 19 3	+0.16	1, 1	g	388s, Red	Hl	
10	18 56 18	− 18.11	19 21 51	+3.96	1, 2	f	388s, Red	Hl	
19	11 39 50	− 13.01	. . .		1, 0	f g	388s, Red	Hl	Very faint.
1913									
Dec. 27	15 23 12	− 27.37			1, 0	g	360r, Blk	Bn	Very faint. Unsatisfactory.
29	19 13 59	− 36.84	19 21 50	−3.12	1, 1	f g	360r, Blk	Bn	
29	19 14 24	− 11.42	19 29 16	3.80	1, 1	f g	360r, Blk	Bn	
30	17 16 32	+ 11.80	17 27 11	−6.19	1, 1	f g	360r, Red	Bn	Very faint. Perhaps haze. Pos-
30	17 11 4	+ 38.68	17 21 22	−6.31	1, 1	f g	360r, Red	Bn	[sibly not *Deimos* in 2c.
1914									
Jan. 5	20 11 11	+ 19.79	20 22 16	+0.56	1, 1	f	360r, Blk	Bn	Very faint. Objectglass slightly
5	20 11 6	+ 51.50	20 31 56	+0.62	1, 1	f	360r, Blk	Bn	[fogged.
7	17 19 58	− 19.03	17 28 1	−0.25	1, 1	g	360r, Blk	Bn	Faint. Moonlight. Haze.
9	17 13 20	+ 18.80	17 19 27	−2.30	1, 1	p	360r, Red	Bn	Very faint. Moonlight. Wind.
9	18 18 50	+ 16.98	18 1 12	−1.22	1, 1	p	360r, Red	Bn	
21	11 41 45	− 16.71			1, 0	f	360r, Blk	Bn	Clouds. Windy.
1916									
Feb. 3	16 15 28	+ 16.39	17 5 35	+0.22	2, 2	f	360r, Red	Hl	Very faint.
		$\cos\delta\,\Delta\alpha$		$\Delta\delta$					
1922									
May 22	17 31 0	− 56.28	18 20 1	+27.60	1, 1	f	360r,	Hl	Faint.
29	17 3 19	+ 57.16	17 20 1	−31.77	1, 1	f	360r, Red	Hl	
29	17 52 38	+ 53.00	17 35 2	−33.30	1, 1	f	360r, Red	Hl	
		p		s					
		°		″					
Jun. 3	17 13 36	118.23	17 12 33	67.63	1, 1	f	360r, Red	Hl	
15	15 27 59	298.97	15 29 18	70.27	1, 1	f	360r, Red	Hl	
25	15 57 10	296.13	16 56 39	67.31	2, 1	f	360r, Red	Hl	Very faint. Haze. Too faint to
29	15 28 30	304.80	15 57 19	63.12	2, 1	f	360r, Red	Hl	Too faint to finish. [finish.

Power and Illum.: r = red glass over planet, s = smoked cover glass over planet, Red = red wires, Blk = black wires.

The measures are corrected for refraction, error in setting, second differences of motion, and phase.

The settings for $\Delta\alpha$ and $\Delta\delta$ are 90° and 0° from the position angle of the rotation axis as given in the *British Nautical Almanac*.

U. S. Naval Observatory, Washington, D. C.,
1923, June 26.

OBSERVATIONS OF SATELLITES OF *URANUS*, 1922,

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

By ASAPH HALL AND ERNEST CLARE BOWER

(Communicated by CAPTAIN W. D. MACDOUGALL, U. S. Navy, Superintendent of U. S. Naval Observatory.)

Date		G. M. T.	p	G. M. T.	s	Comp.	Seeing	Power	Obs.	Remarks
				Titania	*Uranus*					
		h m s	°	h m s	″					
1922 Aug.	21	16 23 22	337.77	16 19 49	16.15	4, 4	g	195	H	Faint. Haze.
	22	17 39 35	343.77	17 43 7	30.20	4, 4	f	495	H	Haze.
Sept.	11	16 21 26	169.14	16 18 20	26.56	4, 4	p	495	B	Faint.
	22	15 41 18	165.61	15 34 42	31.53	4, 4	p	495	B	Faint.
	26	14 24 0	343.92	14 25 31	30.43	4, 5	f	195	B	
				Oberon	*Uranus*					
1922 Aug.	15	16 37 6	164.65	16 35 9	14.84	4, 4	f g	195	H	Faint. Haze. Fog.
	21	17 21 19	342.99	17 21 23	38.17	4, 4	g	495	H	Haze.
	22	19 4 6	345.05	19 6 38	14.86	4, 4	f	495	H	Haze.
	28	16 23 56	163.74	16 30 25	39.86	4, 4	f	495	B	
Sept.	25	14 34 11	165.81	14 39 0	12.00	4, 4	f	495	B	Faint.
	26	15 32 47	169.31	15 31 1	31.61	4, 4	f	495	B	Faint.

U. S. Naval Observatory, Washington, D. C.,
1923, July 27.

SATELLITE VIII OF *JUPITER*.

By GEO. VAN BIESBROECK.

During the spring of 1923 only two nights proved sufficiently good for getting exposures on this faint satellite with the 24-inch reflector. In each case the guiding was done so that the plate would follow the motion of the satellite. Two exposures were always obtained in immediate succession in order to locate the object without difficulty in the blink-comparator. Only the better plate of each pair was measured. The satellite was referred differentially to a faint neighboring star on the plate. The positions of the two faint stars were obtained visually, with the 40-inch refractor, by connecting them respectively to A. G. Wash. 5414 and 5398. On May 9, with a 60 min. exposure, the image was faint but distinct. On June 16, shortly after resilvering the mirror, a 75 min. exposure gave a strong image; according to S. B. NICHOLSON (*P. A. S. P.*, Vol. 35, p. 217) the brightness on that date was only $17^{m}.8$, after correcting for absorption.

The results of the measures are as follows:

1923 G. M. T.	(1923.0)	
May 9.73743	$14^{h}42^{m}34^{s}.21$	$-15°25'34''.6$
June 16.69146	14 28 48 .31	-14 33 0 .9

I hope to be able to photograph the object even in the coming unfavorable oppositions.

Yerkes Observatory,
August 26, 1923.

CONTENTS.

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OBSERVATIONS DE PLANÈTES ET DE COMÈTES,

FAITES À L'OBSERVATOIRE DE BESANÇON, ÉQUATORIAL COUDÉ DE 0m.33 d'ouverture.

PAR M. P. CHOFARDET.

Dates	T. m. Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app	log f.p.	D.P. app.	log f.p.	Réd. au j.		★
					(11) *Parthénope*						
1922	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Mars 16	9 42 10	−2 15.90	− 4 20.8	9, 12	8 2 40.75	9.137	68 20 3.1	0.591*n*	+1.63	+12.1	1
17	10 12 51	−2 15.41	− 5 16.9	9, 12	8 2 41.22	9.296	68 19 7.0	0.605*n*	+1.61	+12.1	1
18	10 1 56	−2 13.32	− 6 6.1	9, 12	8 2 43.30	9.269	68 18 17.4	0.602*n*	+1.60	+12.0	1
					(33) *Polyhymnie*						
Nov. 15	8 34 22	−2 22.70	− 1 45.0	6, 8	2 15 24.85	9.333*n*	74 19 38.7	0.684*n*	+4.15	−15.0	2
16	8 5 2	+2 59.09	− 9 31.6	9, 12	2 14 13.52	9.403*n*	74 22 11.5	0.692*n*	+4.13	−15.5	3
					(39) *Laetitia*						
Juil. 20	11 2 2	+0 39.42	+ 1 5.2	6, 6	19 34 8.95	8.857*n*	100 9 50.2	0.869*n*	+3.25	−17.1	4
26	10 58 58	−1 40.80	− 0 15.8	9, 6	19 29 11.88	8.423*n*	100 43 21.6	0.873*n*	+3.30	−17.3	5
28	10 51 24	+1 28.18	+15 26.7	9, 6	19 27 36.83	8.531*n*	100 55 6.4	0.874*n*	+3.30	−17.2	6
					(41) *Daphne*						
Oct. 13	10 3 45	−1 56.75	− 7 57.6	9, 9	0 49 54.04	9.134*n*	91 4 44.4	0.818*n*	+3.55	−20.4	7
14	10 29 36	−2 41.42	− 0 17.8	9, 12	0 49 9.38	8.929*n*	91 12 24.3	0.819*n*	+3.56	−20.3	7
16	11 5 38	−1 23.09	− 7 36.0	9, 6	0 47 41.72	7.777*n*	91 26 6.1	0.812*n*	+3.55	−20.4	8
					(44) *Nysa*						
Août 21	10 40 56	−0 55.37	− 8 5.7	9, 6	21 14 24.37	8.813*n*	106 57 56.3	0.899*n*	+3.42	−21.9	9
24	10 26 12	+3 28.63	− 6 22.7	9, 12	21 11 45.51	8.817*n*	107 13 12.8	0.900*n*	+3.43	−21.7	10
					(48) *Doris*						
Juin 21	10 35 34	−1 39.37	+ 6 13.8	6, 3	18 20 55.48	9.273*n*	104 0 10.8	0.879*n*	+3.08	− 8.0	11
Juil. 20	9 47 18	+1 44.72	− 5 2.4	9, 8	17 59 33.57	8.573*n*	104 24 29.7	0.896*n*	+3.26	−10.9	12
21	9 51 41	+1 9.40	− 3 28.9	9, 6	17 58 58.25	8.322*n*	104 26 3.1	0.890*n*	+3.26	−11.0	12
26	10 7 43	−1 31.45	+ 5 0.5	9, 6	17 56 17.38	8.679	104 34 32.4	0.890*n*	+3.24	−11.1	12
28	10 16 8	−2 28.54	+ 8 42.3	9, 12	17 55 20.28	8.897	104 38 14.2	0.889*n*	+3.23	−11.1	12
Août 16	9 49 3	−1 38.07	− 0 3.7	9, 6	17 50 19.25	9.230	105 18 31.7	0.885*n*	+3.07	−10.9	13

1922		T.m.	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log f.p.	Réd. au j.		★
						(19) *Fides*						
		h m s	m s	′ ″		h m s		° ′ ″		s	″	
[illegible]	18	[illegible] 52 [illegible]	[illegible]	2 2.7	9, 6	21 23 9.65	8.901n	102 27 18.6	0.880n	+3.37	−22.4	14
	19	[illegible] 57 55	[illegible]	1 54.1	9, 6	21 22 21.78	9.218n	102 30 10.0	0.876n	+3.37	−22.4	14
						(67) *Asia*						
Oct.	1[illegible]	10 37 5[illegible]	1 [illegible].21	+11 51.1	9, 6	1 31 28.11	9.192n	80 9 44.5	0.737n	+3.77	−17.8	15
	17	10 56 30	0 [illegible].78	−10 58.7	9, 6	1 33 21.01	9.001n	80 18 36.9	0.732n	+3.77	−17.8	16
	1[illegible]	[illegible]1 21 55	2 [illegible].57	− 1 11.7	9, 12	1 31 45.11	8.703n	80 36 29.2	0.732n	+3.78	−17.9	17
Nov.	[illegible]	8 5 6	2 11 [illegible]	− 3 11.1	9, 12	1 11 51.31	9.225n	84 3 55.1	0.768n	+3.69	−19.2	18
	[illegible]	7 58 [illegible]	2 [illegible] [illegible]7	− 3 17.7	9, 12	1 11 7.91	9.210n	84 13 42.3	0.769n	+3.68	−19.4	19
	[illegible]	7 [illegible] [illegible]	−1 39.[illegible]2	− 1 12.9	9, 12	1 10 47.39	9.303n	84 18 12.9	0.771n	+3.68	−19.4	19
						(74) *Galatea*						
Août	[illegible]8	11 19 4[illegible]	0 44.[illegible]5	− 0 6.8	9, 6	20 34 23.31	8.744n	102 17 6.0	0.880n	+3.38	−20.9	20
	[illegible]	9 39 41	1 2.06	+ 0 27.7	9, 6	20 33 12.71	9.056n	102 21 26.3	0.878n	+3.38	−20.9	21
						(90) *Antiope*						
Oct.	1[illegible]	10 6 48	−0 2[illegible].10	+ 9 2.7	9, 6	0 16 24.58	8.734n	91 26 52.9	0.820n	+3.51	−21.9	22
	17	9 44 32	[illegible] 15.10	− 7 52.9	9, 12	0 15 48.61	8.955n	91 29 58.5	0.818n	+3.51	−21.8	23
						(100) *Hécate*						
Juin	20	11 15 29	2 35.02	+ 9 8.0	9, 12	17 25 19.24	8.468n	106 11 45.9	0.897n	+3.15	− 7.5	24
	21	11 10 24	+1 51.48	+11 3.3	9, 6	17 24 28.86	8.380	106 12 37.9	0.897n	+3.15	− 7.1	25
Août	16	9 15 46	−2 6 44	8 30.9	9, 6	17 7 2.92	9.282	108 44 31.8	0.895n	+2.96	− 6.6	26
						(118) *Peitho*						
Mai	23	11 22 29	−2 12.58	− 1 45.7	6, 8	15 5 36.55	8.567	108 17 3.3	0.996n	+2.90	+ 4.1	27
						(122) *Gerda*						
Mai	22	10 12 57	−2 16.00	−10 29.0	9, 12	11 5 26.38	9.467	83 58 36.4	0.777n	+1.49	+12.2	28
	23	10 8 29	−3 12.7[illegible]	8 3.4	9, 12	11 5 53.16	9.464	84 1 4.6	0.778n	+1.48	+12.1	28
	24	10 2 9	3 10.54		3	11 6 20.87	9.460	....	.....	+1.47	+12.0	28
						(124) *Alceste*						
M[illegible]	16	10 12 4	+1 23.76	7 50.1	9, 6	12 5 51.50	9.359n	91 27 13.2	0.819n	+2.09	+13.2	29
	17	11 11 45	3 4.33	4 12.3	9, 12	12 5 3.82	9.408n	91 20 22.0	0.819n	+2.10	+13.2	30
						(130) *Electra*						
M[illegible]	[illegible]7	9 17 [illegible]2	+0 50.72	1 5.0	9, 6	7 25 29.48	9.192	77 19 30.7	0.706n	+1.41	+14.2	31
	[illegible]8	9 [illegible] [illegible]	0 51.65	− 7 11.8	9, 6	7 25 12.69	9.219	77 12 39.3	0.706n	+1.39	+14.1	32

Dates	T. m. Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log. f.p.	Réd. au j.		★
					(198) *Ampella*						
1922	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Nov. 13	6 56 56	−2 41.90	− 9 28.3	9, 12	0 20 18.27	9.326*n*	72 21 10.5	0.661*n*	+3.69	−24.7	33
15	6 31 40	+1 37.01	− 0 18.8	9, 8	0 20 47.52	9.304*n*	72 38 36.9	0.669*n*	+3.65	−25.0	34
16	6 52 58	+1 55.11	+ 7 30.0	9, 12	0 21 5.61	9.280*n*	72 46 55.7	0.661*n*	+3.64	−25.0	34
17	6 29 4	+1 52.08	+ 0 53.3	9, 12	0 21 25.71	9.348*n*	72 54 49.7	0.670*n*	+3.63	−24.9	35
					(203) *Pompeja*						
Mars 17	10 42 1	+0 32.19	− 5 48.6	9, 6	9 58 29.32	8.662	76 37 48.4	0.696*n*	+1.91	+15.0	36
18	10 49 7	−0 4.61	− 7 46.4	9, 6	9 57 52.52	8.787	76 35 50.6	0.691*n*	+1.91	+15.0	36
					(287) *Nephthys*						
Dec. 21	7 9 32	−0.17.34	+ 2 41.5	9, 8	2 25 33.22	9.125*n*	90 28 11.1	0.814*n*	+3.70	− 9.2	37
					(336) *Lacadiera*						
Juil. 20	11 27 29	+0 53.46	− 2 26.7	9, 6	19 56 3.35	8.814*n*	100 42 27.2	0.873*n*	+3.24	−18.0	38
26	11 44 7	+3 35.05	− 5 37.8	6, 8	19 50 7.75	8.218	100 51 50.0	0.872	+3.30	−18.0	39
28	11 18 20	+1 41.27	− 1 45.9	9, 6	19 48 13.98	8.048*n*	100 55 41.8	0.874*n*	+3.31	−18.1	39
					(377) *Campania*						
Mai 19	10 41 3	+1 27.81	− 3 16.2	9, 6	12 5 59.94	9.368	92 20 10.5	0.824*n*	+1.93	+12.8	40
22	10 44 28	−1 13.81	+ 7 13.4	9, 6	12 6 10.07	9.466	92 23 43.7	0.823*n*	+1.92	+12.5	41
					(444) *Gyptis*						
Mai 19	11 9 47	+1 32.92	+ 2 39.9	9, 6	12 11 56.29	9.415	90 55 17.7	0.816*n*	+1.96	+12.0	42
22	11 15 3	+3 40.49	− 6 27.0	9, 12	12 14 42.96	9.452	90 47 20.5	0.815*n*	+1.92	+11.9	43
23	10 45 30	+3 38.60	− 8 41.7	9, 12	12 14 41.06	9.397	90 45 2.7	0.815*n*	+1.91	+11.8	43
					(446) *Aeternitas*						
Nov. 21	6 56 52	−1 25.09	+ 6 32.0	9, 6	23 26 31.55	8.728*n*	101 31 44.7	0.877*n*	+2.98	−18.5	44
					(451) *Patientia*						
Mars 16	9 9 49	−2 57.80	− 5 1.9	9, 12	7 56 31.23	9.002	56 2 3.8	0.346*n*	+1.71	+ 8.3	45
17	9 42 41	−2 51.73	− 3 37.7	9, 12	7 56 37.28	9.211	56 3 27.9	0.349*n*	+1.69	+ 8.2	45
18	9 40 13	−2 43.96	− 2 7.8	9, 12	7 56 45.03	9.218	56 4 57.7	0.351*n*	+1.67	+ 8.4	45
					(478) *Tergeste*						
Oct. 13	9 27 36	+1 12.70	− 6 28.1	9, 6	0 32 11.01	9.217*n*	73 3 51.2	0.661*n*	+3.82	−22.4	46
14	9 54 21	−0 46.22	−11 36.7	9, 6	0 31 28.92	9.085*n*	73 12 17.2	0.654*n*	+3.82	−22.4	47
16	10 39 14	+1 2.10	+10 35.2	9, 6	0 30 1.96	8.350*n*	73 29 10.9	0.652*n*	+3.81	−22.8	48
17	10 10 55	+2 29.99	+ 6 31.5	9, 12	0 29 25.15	8.826*n*	73 37 30.0	0.655*n*	+3.80	−23.6	49
Nov. 13	7 29 40	+3 56.11	+ 1 25.2	9, 12	0 17 10.23	9.111*n*	77 19 0.4	0.765*n*	+3.55	−24.2	50
15	6 57 48	−0 40.72	− 6 12.1	9, 8	0 16 50.48	9.250*n*	77 33 7.3	0.711*n*	+3.55	−23.9	51
16	7 14 25	−0 18.89	+ 0 16.1	8, 8	0 16 12.30	9.157*n*	77 40 3.0	0.709*n*	+3.54	−23.9	51

	t	ΔA.R.	ΔD.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log f.p.	Réd. au j.		★
					(485) *Genua*						
1922	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Oct. 14	9 21 16	0 9.65	1 29.4	9, 6	23 5 7.82	8.344*n*	89 52 28.0	0.810*n*	+3.35	−21.5	52
16	9 31 58	2 34.75	+ 9 21.5	9,12	23 1 19.83	8.464	90 9 47.7	0.812*n*	+3.34	−24.6	53
17	9 19 17	2 35.41	− 2 22.9	9, 9	23 3 57.75	7.618*n*	90 17 31.4	0.810*n*	+3.31	−24.4	54
					(776) *Berbericia*						
Nov. 21	7 56 5	−0 48.15	− 7 26.9	9, 8	1 18 54.35	9.254*n*	104 12 40.9	0.881*n*	+3.38	−13.5	55
					(925) *Alphonsina*						
Août 16	11 15 3	1 1.80	+ 1 18.9	9, 6	21 40 34.97	8.915*n*	88 4 14.6	0.797*n*	+3.31	−22.5	56
17	11 12 32	−2 2.15	+ 0 25.3	9,12	21 39 34.62	8.894*n*	88 3 17.9	0.796*n*	+3.34	−22.6	56
18	10 22 10	+1 13.38	+ 1 23.3	9, 6	21 38 36.31	9.188*n*	88 2 31.2	0.797*n*	+3.32	−22.7	57
19	10 15 16	+0 13.12	+ 0 45.2	9, 6	21 37 36.05	9.495*n*	88 1 53.0	0.797*n*	+3.32	−22.8	57
					Comète 1922*b* (Skjellerup)						
Mai 19	9 39 7.5	+0 45.20	− 1 30.7	6, 9	8 4 26.43	9.626	68 35 17.8	0.750*n*	+0.57	+ 9.9	58
20	9 43 10.7	−2 4.21	+ 4 3.0	9, 6	8 9 26.74	9.632	67 39 33.0	0.750*n*	+0.59	+ 9.5	59
22	9 39 40.4	+4 5.25	− 0 55.3	9,12	8 19 59.97	9.637	65 43 4.1	0.736*n*	+0.58	+ 8.8	60
23	9 37 34.9	−1 13.94	− 3 32.5	9, 6	8 25 37.38	9.640	64 41 56.6	0.727*n*	+0.61	+ 8.4	61
24	9 37 48.7	−2 0.89	− 1 38.0	9, 6	8 31 29.86	9.644	63 38 48.7	0.720*n*	+0.62	+ 8.0	62
28	9 52 7.1	+3 47.25	− 3 40.2	9,12	8 57 52.76	9.662	59 10 15.9	0.697*n*	+0.62	+ 6.2	63
29	9 50 4.0	+4 7.88	+ 2 54.2	9,12	9 5 16.44	9.665	58 0 4.0	0.683*n*	+0.63	+ 5.7	64
30	10 25 40.8	−3 29.43	+ 1 0.6	9,12	9 13 14.84	9.679	56 47 0.2	0.743*n*	+0.66	+ 4.9	65
31	11 10 38.0	−4 26.62	+ 6 6.8	6, 8	9 21 44.82	9.685	55 32 55.3	0.754*n*	+0.68	+ 4.3	66
Juin 27	10 44 15.2	−5 43.32	− 0 7.5	9,12	14 49 13.21	9.497	45 12 59.8	0.029*n*	+1.85	−11.1	67
					Comète 1922*c* (Baade)						
Oct. 24	6 25 37	−0 10.68	− 1 49.7	9, 6	19 57 13.02	8.944	53 35 35.8	0.223*n*	+1.84	−32.5	68
24	7 25 26	−0 35.05	− 1 6.5	9, 6	19 57 18.65	9.312	53 36 19.0	0.289*n*	+1.84	−32.5	68
28	7 11 2	+0 5.60	+ 0 58.5	9, 3	20 6 24.84	9.285	54 45 10.2	0.318*n*	+1.85	−32.6	69
Nov. 11	7 1 10	−1 20.22	+ 0 39.4	9,12	20 39 57.98	9.316	58 46 26.9	0.436*n*	+1.96	−32.4	70
12	6 27 29	0 38.73	+ 5 22.1	9, 6	20 42 22.24	9.145	59 2 55.9	0.413*n*	+1.96	−32.3	71
13	5 51 27	+0 57.28	− 2 2.4	9, 6	20 44 37.65	8.851	59 19 26.6	0.402*n*	+1.95	−32.2	72
15	5 56 24	+0 32.60	− 2 31.3	9, 8	20 49 45.42	8.932	59 52 57.8	0.418*n*	+1.98	−32.1	73
16	5 56 40	−3 0.39	− 2 15.5	9,12	20 52 14.81	8.950	60 9 34.3	0.426*n*	+2.02	−32.2	74
17	5 59 10	+0 29.76	− 1 55.0	9, 8	20 54 44.91	8.985	60 26 8.2	0.434*n*	+1.99	−32.0	75
21	5 11 56	−0 33.12	+ 1 2.5	9, 8	21 4 14.39	8.899	61 31 0.2	0.456*n*	+2.04	−31.8	76
24	6 18 16	+0 4.53	+ 0 27.3	9, 8	21 12 20.19	9.169	62 18 48.6	0.488*n*	+2.06	−31.5	77
25	7 21 29	−1 25.46	+ 4 10.7	9, 8	21 14 57.43	9.419	62 35 4.7	0.512*n*	+2.08	−31.4	78
Déc. 8	5 17 29	−0 57.15	+ 1 19.1	9, 8	21 47 24.71	9.102	65 42 2.1	0.546*n*	+2.20	−30.1	79
14	6 33 48	−0 10.19	− 0 33.8	9, 8	22 2 16.03	9.345	66 59 21.5	0.591*n*	+2.25	−29.3	80
21	6 11 12	−0 51.02	+ 3 11.7	9, 8	22 19 17.15	9.299	68 20 2.9	0.606*n*	+2.31	−28.2	81
1923											
Janv. 12	7 5 57	+3 13.44	+ 2 39.2	9,10	23 10 39.37	9.540	71 32 42.0	0.709*n*	−0.54	− 5.0	82
17	6 21 40	−2 39.57	+11 10.0	3, 3	23 21 41.20	9.443	72 4 14.2	0.676*n*	−0.50	− 3.8	83

Dates	T. m Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log f.p.	Réd. au j.		★
Comète 1922c (Baade) (suite)											
1923	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Janv. 19	6 24 36	−1 8.75	+ 8 16.2	9, 8	23 26 4.27	9.456	72 15 44.6	0.682n	−0.50	− 3.3	84
Févr. 6	6 46 59	+2 22.18	− 1 2.7	9, 8	0 4 6.91	9.515	73 33 53.6	0.721n	−0.53	+ 0.5	85
9	6 46 51	−0 15.71	− 4 3.9	9, 6	0 10 12.08	9.550	73 43 8.2	0.724n	−0.51	+ 0.8	86

Positions moyennes des étoiles de Comparison.

★	A.R. 1922-23.0	D.P. 1922-23.0	Autorités	★	A.R. 1922-23.0	D.P. 1922-23.0	Autorités
	h m s	° ′ ″			h m s	° ′ ″	
1	8 4 55.02	68 24 11.8	*A.G. Berlin B* 3280	39	19 46 29.46	100 57 45.8	*A.G. Camb. U.S.* 6971
2	2 17 43.40	74 21 38.7	*A.G. Berlin A* 653	40	12 4 30.20	92 33 13.9	rap. à *A.G. Strasb.* 4727
3	2 11 40.30	74 32 28.6	*A.G. Berlin A* 631	41	12 7 21.96	92 15 17.8	*A.G. Nicolajew* 3369
4	19 33 26.28	100 9 2.1	*A.G. Camb. U.S.* 6881	42	12 13 21.11	90 52 25.8	rap. à ★ 43
5	19 30 49.38	100 43 54.7	*A.G. Camb. U.S.* 6867	43	12 11 0.55	90 53 35.6	*A.G. Nicolajew* 3382
6	19 26 5.35	100 39 56.9	*A.G. Camb. U.S.* 6823	44	23 27 53.66	101 25 31.2	*A.G. Camb. U.S.* 8201
7	0 51 47.24	91 13 2.1	*A.G. Nicolajew* 170	45	7 59 27.32	56 6 57.4	*A.G. Leiden* 3379
8	0 49 1.26	91 34 2.5	*A.G. Nicolajew* 163	46	0 30 55.12	73 10 14.7	rap. à ★ 47
9	21 15 16.32	107 6 23.9	*A.G. Washington* 8034	47	0 32 11.32	73 24 14.3	*A.G. Berlin A* 170
10	21 8 13.45	107 19 57.2	*A.G. Washington* 7988	48	0 28 59.05	73 18 58.5	*A.G. Berlin A* 149
11	18 22 31.77	103 54 5.0	*A.G. Camb. U.S.* 6302	49	0 26 51.36	73 31 21.5	*A.G. Berlin A* 128
12	17 57 45.59	104 29 43.0	*A.G. Washington* 6495	50	0 13 10.57	77 17 59.4	rap. à *A.G. Lpz. I* 64
13	17 51 54.25	105 18 46.3	*A.G. Washington* 6450	51	0 16 57.65	77 39 41.4	*A.G. Leipzig I* 88
14	21 22 10.87	102 25 38.3	*A.G. Camb. U.S.* 7600	52	23 4 54.82	89 51 23.4	*A.G. Nicolajew* 5786
15	1 33 11.40	79 58 8.2	*A.G. Leipzig II* 601	53	23 6 51.24	90 0 20.8	*A.G. Nicolajew* 5787
16	1 34 26.05	80 29 53.4	*A.G. Leipzig II* 614	54	23 1 19.00	90 20 18.7	*Munich₂* 12834
17	1 33 50.20	80 37 58.8	*A.G. Leipzig II* 605	55	1 19 39.12	104 19 51.3	*A.G. Washington* 347
18	1 9 8.74	84 7 25.7	rap. à ★ 19	56	21 41 33.46	88 3 15.2	*A.G. Albany* 7597
19	1 9 4.09	84 17 19.1	*A.G. Leipzig II* 430	57	21 36 49.61	88 1 30.6	*A.G. Albany* 7575
20	20 33 35.08	102 17 20.1	*A.G. Camb. U.S.* 7299	58	8 3 40.66	68 39 38.6	rap. à *A.G. Berl.B* 3241
21	20 34 41.42	102 21 19.5	*A.G. Camb. U.S.* 7308	59	8 11 30.36	67 35 20.5	*A.G. Berlin B* 3314
22	0 16 50.17	91 18 12.1	*A.G. Nicolajew* 15	60	8 15 54.14	65 43 50.6	*A.G. Berlin A* 2314
23	0 17 29.20	91 22 27.4	*A.G. Nicolajew* 17	61	8 26 50.71	64 45 20.7	*A.G. Camb. E* 4563
24	17 27 51.11	106 2 15.4	*A.G. Washington* 6287	62	8 33 30.13	63 40 18.7	*A.G. Camb. E* 4618
25	17 22 34.23	106 1 41.7	*A.G. Washington* 6252	63	8 51 1.89	59 13 19.9	*A.G. Leiden* 3711
26	17 9 6.37	108 53 9.3	rap. à Bordeaux 4908	64	9 1 7.93	57 57 4.1	*A.G. Leiden* 3751
27	15 7 46.23	108 48 44.9	*Paris* 18788	65	9 16 13.61	56 45 54.7	*A.G. Leiden* 3833
28	11 2 38.89	84 8 52.9	*A.G. Leipzig II* 5686	66	9 26 7.76	55 26 44.2	*A.G. Leiden* 3888
29	12 7 16.17	91 34 50.4	*A.G. Nicolajew* 3368	67	14 54 54.68	45 13 18.4	*A.G. Bonn* 9707
30	12 8 6.05	91 24 21.1	rap. à ★ 29	68	19 57 51.86	53 37 58.0	*A.G. Lund* 8930
31	7 24 57.35	77 23 21.5	*A.G. Leipzig I* 2937	69	20 6 17.36	54 44 44.3	*A.G. Lund* 9069
32	7 24 49.65	77 4 43.4	*A.G. Leipzig I* 2934	70	20 11 16.24	58 46 19.9	*A.G. Leiden* 8445
33	0 22 56.48	72 31 39.5	*A.G. Berlin A* 100	71	20 12 59.01	58 58 6.1	*A.G. Leiden* 8462
34	0 19 6.86	72 39 50.7	*A.G. Berlin A.* 78	72	20 13 38.42	59 22 0.9	*A.G. Leiden* 8472
35	0 19 30.03	72 54 21.3	*A.G. Berlin A* 82	73	20 19 10.84	59 56 1.2	*A.G. Camb. E* 11863
36	9 57 55.22	76 43 22.0	*A.G. Leipzig I* 3924	74	20 55 13.21	60 7 51.0	*A.G. Camb. E* 11971
37	2 26 16.86	90 26 11.8	*A.G. Nicolajew* 502	75	20 51 13.22	60 28 35.2	*A.G. Camb. E* 11943
38	19 55 6.65	100 45 11.9	*A.G. Camb. U.S.* 7034	76	21 5 15.77	61 30 29.5	*A.G. Camb E* 12172

★	A.R. 1922-23.0	D.P. 1922-23.0	Autorités		★	A.R. 1922-23.0	D.P. 1922-23.0	Autorités	
	h m s	° ′ ″				h m s	° ′ ″		
77	21 12 13.60	62 18 52.8	*A.G. Camb. E*	12296	82	23 6 56.47	71 30 7.8	*A.G. Berlin A*	9480
78	21 16 20.81	62 31 25.1	*A.G. Camb. E*	12371	83	23 21 21.27	71 53 8.0	*A.G. Berlin A*	9581
79	21 18 16.66	65 10 13.1	*A.G. Berlin B*	8432	84	23 27 13.52	72 7 31.7	*A.G. Berlin A*	9596
80	22 2 53.97	67 0 24.6	*A.G. Berlin B*	8522	85	0 1 15.26	73 31 55.8	*A.G. Berlin A*	9781
81	22 20 5.86	68 17 19.1	*A.G. Berlin B*	8624	86	0 10 28.30	73 17 11.3	*A.G. Berlin A*	37

REMARQUES

Planètes (18) et (122) — Juin 21, Mai 24: les observations sont contrariées par les nuages.

Comète 1922 *b* (SKJELLERUP) — Mai 19, comète faible, de grandeur 12.5, large de 1′ au maximum, condensation incertaine et décentrée. Mai 24, comète plus visible, estimée de grandeur 11.5. Mai 31, comète très faible, pénible à observer. Juin 27, comète à peine perceptible, plus petite que 12.5.

Comète 1922 *c* (BAADE) — Octobre 21, comète de 11^e grandeur, tête ronde, large auplus de 20″, avec noyau central; la chevelure est un peu allongée vers l'Est. October 28, cet astre est bien observable malgré la présence de la Lune agée de 8 jours. November 11, comète de 10^e grandeur, noyau bien apparent, chevelure large de 1′ et comme soufflée vers le NE. Novembre 21, comète de 9^e grandeur, condensation bien définie, naissance de queue vers NE. Décembre 21, même aspect de la comète. Janvier 12, comète de grandeur 10.5, large de 45″, avec noyau toujours décentré. Janvier 17, le ciel se couvre rapidement. Février 6, comète de grandeur 11.5, chevelure de 20″ de diamètre, un peu allongée vers le Nord.

Observatoire de Besançon,
3 Octobre, 1923.

OBSERVATIONS OF SATELLITE VI OF *JUPITER*,

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

BY ERNEST CLARE BOWER.

[Communicated by CAPTAIN E. T. POLLOCK, U. S. Navy, Superintendent.]

G. M. T.	App. α	App. δ	Obj − ★		Comp.	log pρ		Ap.pl. red. of ★		Seeing	★
	h m s	° ′ ″	s	′ ″				s	″		
1922 May 29.68494	12 31 16.45	− 2 22 48.8	− 2.47	−3 54.0	*d*10, 8	9.527	0.755	+1.99	−11.0	*f*	1
1923 Apr. 18.79197	11 52 6.38	−15 7 1.6	−11.54	+3 28.8	*d*10, 8	9.007	0.848	+2.08	− 2.8	*f*	2

May 29 14ᵐ ±. Faint.

Mean Places of Comparison Stars for Beginning of Year

★	α	δ	Authority
	h m s	° ′ ″	
1	12 31 46.93	− 2 18 13.8	$\frac{1}{2}$ Ast (Alg −2°1232, 97 + Fer −3°1228, 76)
2	11 52 15.84	−15 10 27.6	*BD* −14 1071 comp. with 3, 1923 Apr. 18, $\Delta\alpha = -2^m\,20^s.73$,
3	11 54 36.57	−15 7 42.3	*AG Wash* 5529 $\Delta\delta = -2'15''.3$, 1923.0

U. S. Naval Observatory, Washington, D. C.,
1923 October 22.

PHOTOGRAPHIC DETERMINATIONS OF THE PARALLAXES OF 50 STARS WITH THE THAW REFRACTOR.

BY BERTHA G. GRIER.

The mean number of plates used in these determinations is 20.7, and the mean number of comparison stars is 4.0. The mean probable error is ±.0060. Seven plates were rejected after measurement.

The column headed "A. O. α" gives the proper-motion of the parallax star in right ascension relative to the comparison stars. The preceding column gives the absolute motion in right ascension as measured by BOSS or PORTER. The column headed "P.E." gives, — first the probable error of the parallax, then the probable error of weight unity, both expressed in thousandths of a second of arc. The last column gives the sector opening in per cent: an opening of 1.00 per cent indicates a reduction of about five magnitudes.

The numbers are in continuation of earlier series. The work will appear in detail in *Publications of the Allegheny Observatory*.

Acknowledgments are due to Directors SHAPLEY, PORTER, and BOSS for data concerning magnitude, spectral class and proper-motion, and to DR. KEIVIN BURNS for helpful advice and supervision.

Allegheny Observatory,
October 15, 1923.

No.	Name	α (1900)	δ (1900)	DM. No.	Vis. Mag. Class	Proper-Motion Catalog Total	Proper-Motion Catalog α	Proper-Motion A. O. α	Relative Parallax and P. E.		Sector %
		h m	° ′			″	″	″	″		
593	*Lal.* 1677	0 54.1	+31 57	+31 153	7.0 F5	0.358	+0.355	+0.248	+.030	±7:24	1.5
594	37 *Ceti*	1 09.4	− 8 28	− 8 210	5.2 F0	.295	+ .128	+ 81	+ 35	8:27	1.0
595	*Pi.* 171	1 43.0	+32 11	+31 316	5.8 F5	.352	− .174	− .179	+ 28	7:27	1.3
596	48 *Cassiopeiæ*	1 53.7	+70 25	+70 153	4.6 A3	61	− 61	− 70	+ 22	6:22	1.0
597	64 *Ceti*	2 06.1	+ 8 06	+ 7 347	5.7 G0	.173	− .134	− .188	+ 30	6:21	1.0
598	*Lal.* 5490	2 56.0	+61 20	+61 513	6.7 G0	1.004	+ .724	+ .745	+ 18	5:18	12.0
599	σ *Aurigæ*	5 17.9	+37 18	+37 1175	5.2 F5	0.027	0	− 4	+ 1	4:16	1.5
600	75 *Orionis*	6 11.6	+ 9 59	+ 9 1173	5.3 A2	63	+ 6	+ 10	+ 10	5:20	0.5
601	63 *Aurigæ*	7 04.8	+39 29	+39 1882	5.1 K2	18	+ 48	+ 18	+ 19	6:23	2.5
602	51 *Gem.*	7 07.6	+16 20	+16 1417	5.3 M1	51	+ 14	+ 12	+ 6	6:24	3.0
603	65 *Aurigæ*	7 15.1	+36 57	+37 1707	5.2 K0	88	− 78	− .109	+ 19	6:23	2.3
604	65 *Gem.*	7 23.6	+28 07	+28 1440	5.1 K0	17	− 26	− 52	+ 13	5:18	1.3
605	68 *Gem.*	7 27.9	+16 02	+16 1510	5.1 A2	27	− 12	− 11	+ 8	4:16	0.5
606	*Lal.* 15307	7 48.6	+50 48	+50 1489	8.5 G5	.224	+ .177	+ .203	+ 4	6:21	30.0
607	*Lal.* 15882	8 03.7	+35 15	+35 1767	6.6 F8	.333	+ .223	+ .209	+ 19	4:16	2.0
608	*Lal.* 16530	8 20.5	+ 7 53	+ 8 2073	5.2 F0	.040	− .040	− .023	+ 3	8:28	0.8
609	Σ 1245	8 30.5	+ 6 58	+ 7 1997	6.0 F5	.193	− .122	− .114	+ 48	7:27	1.5
610	7 *Leonis*	9 30.1	+14 50	+15 2077	6.2 A0	38	− 36	− .116	− 1	6:21	5.0
611	*Lal.* 19022	9 37.1	+43 16	+43 1953	8.1 F2	.849	+ 41	+ 41	+ 64	6:21	15.0
612	*Lal.* 19149	9 51.5	+20 11	+20 2399	7.7 G0	.242	− .242	− .247	+. 20	5:20	20.0
613	*Lal.* 19149	9 51.5	+20 11	... ...	... ...	...	......	− .240	+ 31	6:24	20.0
	Mean								+ 25	4:—	
614	ν *Bootis*	15 27.3	+11 10	+11 2809	5.2 K5	20	+ 14	+ 13	+ 17	5:18	1.5
615	ι *Serpentis*	15 37.1	+20 00	+20 3138	4.5 A2	87	− 68	− 57	+ 1	7:26	0.3
616	*Lal.* 29439	16 02.9	+39 55	+39 2970	8.6 G5	.591	+ .226	+ .240	+ 50	9:30	12.0
617	*Lal.* 29957	16 16.5	+67 29	+67 935	8.9 F5	.505	− .497	− .491	+. 83	5:19	25.0

No.	Name	α 1900	δ 1900	DM. No.	Vis. Mag. Class	Proper-Motion Catalog Total	Proper-Motion Catalog α	Proper-Motion A. O. α	Relative Parallax	and P. E.	Sector %
		h m	° ′			″	″	″	″		
618	[illegible] 2624	18 34.9	+42 35	+42 3123	8.7 G5	0.302	+0.295	+0.299	+.015	±7;25	40.0
619	[illegible] 2686	18 48.0	+38 30	+38 3327	7.2 F8	.312	+ .311	+ .330	+ 11	8;24	3.0
620	[illegible] 273	18 49.8	+74 36	+74 792	7.3 G0	.333	+ .327	+ .339	− 16	7;20	5.0
621	[illegible]	19 20.2	+65 31	+65 1345	4.6 A2	46	+ 22	+ 39	+ 8	7;23	0.6
622	*Lal.* 37272	19 31.7	+51 01	+50 2845	5.6 F5	.207	+ 32	+ 1	+ 32	6;22	2.0
623	[illegible]	19 35.4	+29 55	+29 3684	4.8 K0	34	+ 1	− 4	+ 6	7;24	1.0
624	α *Sagittae*	19 35.6	+17 47	+17 4042	4.4 G0	39	+ 20	+ 14	− 5	5;17	0.5
625	ξ *Cygni*	19 53.0	+52 10	+52 2572	4.8 A3	19	− 37	− 46	− 1	6;21	0.9
626	15 *Vulpec.*	19 57.0	+27 29	+27 3787	4.7 A5	56	+ 56	+ 43	+ 22	6;22	0.6
627	47 *Cygni*	20 30.0	+31 51	+31 1079	4.8 K5	.015	+ .002	− .016	− 2	6;24	2.5
628	29 *Vulpec.*	20 34.1	+20 51	+20 4658	4.8 A0	62	+ 62	+ 78	− 7	7;23	0.8
629	*O*Σ 111	20 59.0	+45 28	+45 3215	7.6 G0	...	...	− 48	+ 6	6;19	18.0
630	31 *Vulpec.*	20 47.8	+26 43	+26 4017	4.8 G5	.402	− 71	− 68	+ 19	6;20	1.4
631	63 *Cygni*	21 03.2	+47 15	+47 3292	4.9 K	17	+ 14	+ 8	+ 7	7;21	3.0
632	2 *Pegasi*	21 25.4	+23 12	+23 4325	4.8 Ma	22	+ 21	+ 20	+ 4	6;17	1.5
633	71 *Cygni*	21 32.9	+39 58	+39 4612	5.4 A5	6	− 2	− 10	+ 12	6;18	0.8
634	14 *Pegas.*	21 45.1	+29 43	+29 4525	5.0 A	11	+ 29	+ 36	− 2	8;26	0.5
635	14 *Cephei*	21 58.7	+57 31	+57 2111	5.5 A	7	− 3	− 13	− 15	6;24	0.8
636	*Pi.* 105	22 02.0	+14 32	+14 4013	5.3 K	19	+ 2	− 27	− 1	5;18	3.5
637	*Lal.* 43674-2	22 28.1	+ 8 57	+ 8 4856	7.8 G5	.279	+ .276	+ .273	+ 18	8;25	25.0
638	κ *Aquarii*	[illegible]	− 4 45	− 4 57[illegible]	5.3 K	.139	− 75	− 67	+ 16	8;28	0.8
639	9 *Lacertae*	22 33.3	+51 02	+50 3770	4.8 A5	.116	− 54	− 55	+ 15	6;19	0.4
640	ο *Pegasi*	22 50.2	+ 8 17	+ 8 4961	5.0 A	75	+ 74	+ 78	− 3	7;26	0.5
641	*Radcliff.* 5911	22 55.9	+56 24	+56 2923	5.5 G	8	+ 5	− 11	− 4	5;16	3.0
642	*Brad.* 3109	23 18.9	+31 59	+31 4901	6.5 F2	.237	+ .233	+ .241	+ 4	8;26	6.0

ERRATA, *A. J.* NOS. 825-826,

BY ERNEST W. BROWN.

p. 71, col. 1, equation 84, for $-\ DuDq$ read $-\frac{1}{2}\ Du\ D \log q$

p. 71, col. 2, equation 85, should read $\Gamma q^{-\frac{1}{2}} = \text{const.} - \int (1 - \Gamma D\theta) \frac{q^{\frac{1}{2}}}{n^2} \frac{\partial R}{\partial \theta}\, d_t$

pp. 73, 74, throughout paragraph 15 replace "e_1", by "η", to avoid confusion with "e_1", in paragraph 16.

Yale University,
Sept. 18, 1923.

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ON THE MOTIONS, PARALLAXES AND LUMINOSITIES OF THE LONG-PERIOD VARIABLES AND OTHER STARS OF LATE SPECTRAL TYPES,

By RALPH E. WILSON.

In an earlier paper[1] the writer has published proper-motions of all the red stars of types *Mc*, *Md* and later for which sufficient observations of position are available. A large proportion of these stars are long-period variables. To complete the data for these variables in order to make some approximations to their mean parallaxes and luminosities, an investigation has been made of the meridian observations of stars of types earlier than *Mc*. Table I presents the proper-motions of 86 variables, presumably of long-period and mainly of spectral classes *Ma* and *Mb*, listed in the same form as those in the paper cited above.

Table I

	Star	α	δ	Sp.	μ_α	μ_α	p.e.	μ_δ	p.e.	μ
		h m	° ′		s	″	″	″	″	″
1	*T Cet* . . .	0 16.7	−20 37	*Mb*	+.0053	+.074	±.010	+.019	±.012	.076
2	*Pi* 78	22.9	−12 12	*Mb*	+ 26	+.038	05	−.012	04	.040
3	*T Scu* . . .	24.3	−38 28	*Mb*	+ 45	+.053	14	−.026	18	.059
4	*Z Scu*	35.0	−34 30	*F8*	+ 267	+.328	08	−.110	08	.346
5	*TT Per* . . .	1 41.0	+53 15	*Mb*	+ 02	+.002	05	+.003	09	.004
6	*RR Eri* . . .	2 47.3	− 8 41	*Mb*	− 09	−.013	10	−.016	07	.021
7	*ρ Per*	58.8	+38 27	*Mb*	+ 121	+.142	01	−.114	02	.182
8	*V Hor*	3 1.0	−59 19	*Mb*	+ 56	+.043	09	−.022	10	.048
9	*UZ Per* . . .	13.9	+31 39		− 09	−.012	08	+.005	10	.013
10	*SS Cep*	33.8	+80 00	*Mb*	− 10	−.003	01	+.019	10	.019
11	+51°762	34.1	+51 11	*F5*	+ 12	+.011	06	+.006	12	.013
12	*X Tau*	47.8	+ 7 29	*F5*	+ 56	+.083	09	−.112	08	.139
13	*SW Per*	4 4.0	+41 57	*Ma*	− 05	−.006	13	−.015	16	.016
14	*T Tau*	16.2	+19 18		+ 06	+.009	13	+.047	12	.048
15	*UZ Aur*	5 8.2	+40 01	*Ma*	+ 41	+.047	17	+.013	22	.050
16	*α Ori*	49.8	+ 7 23	*Ma*	+ 24	+.036	01	+.010	01	.037
17	*HD* 39983	51.0	+22 50	*Mb*	− 11	−.015	13	−.001	14	.015
18	*TV Gem*	6 5.8	+21 54	*Ma*	− 04	−.006	08	−.012	09	.013
19	*η Gem*	8.8	+22 32	*Ma*	− 47	−.065	01	−.020	01	.068
20	*TU Aur*	28.2	+45 42	*Mb*	− 03	−.003	13	−.025	18	.025
21	*HD* 50133	46.7	+ 4 53	*Mb*	− 21	−.031	14	−.007	13	.032
22	*TW Gem*	7 1.3	+22 40	*K5*	+ 07	+.010	11	−.010	12	.014
23	*Y Lyn*	20.9	+46 10	*Mb*	+ 02	+.002	08	−.016	11	.016
24	*Y Gem*	35.3	+20 40		− 15	−.021	10	−.024	10	.032
25	*U CMi* . . .	35.9	+ 8 37	*Mb*	+ 23	+.034	25	−.009	25	.035

	Star		α	δ	Sp.	μ_α	μ_α	p.e.	μ_δ	p.e.	μ
			h m	° ′		s	″	″	″	″	″
26	*T*	*Pup*	7 11.7	−40 21	*Ma*	−.0014	−.016	±.005	−.028	±.006	.032
27	*U*	*Gem*	49.2	+22 16	*Con*	− 17	−.024	13	−.010	13	.047
28	*T*	*Lyn*	8 16.4	+33 51		+ 20	+.025	09	−.014	11	.029
29	*TV*	*Hyd*	31.9	− 9 14	*Mb*	± 00	±.000	10	+.002	10	.002
30	*RS*	*Cam*	36.9	+79 20	*Mb*	+ 57	+.016	01	−.049	10	.052
31	*SW*	*Vel*	40.4	−47 03	*K2*	− 146	−.149	07	+.001	08	.149
32	*RT*	*Cam*	52.9	+44 13	*Ma*	+ 01	+.001	09	−.022	08	.022
33	*S*	*Vel*	9 29.5	−45 01	*Mb*	− 73	−.077	10	+.025	14	.081
34	*R*	*Sex*	37.8	− 7 39	*Mb*	+ 17	+.025	14	−.015	13	.029
35	*Z*	*Leo*	46.4	+27 22	*Mb*	− 14	−.019	17	+.003	14	.019
36	*RR*	*Car*	54.8	−58 23	*Mb*	− 41	−.032	06	+.026	11	.026
37	*U*	*UMa*	10 8.3	+60 31	*Ma*	+ 18	+.013	02	−.004	04	.014
38	*SV*	*UMa*	40.1	+55 33		+ 61	+.001	09	−.018	15	.018
39	*HD*	94613	50.2	−61 30	*K5*	− 35	−.025	05	−.024	08	.035
40	*ST*	*UMa*	11 22.4	+45 44	*Mb*	− 08	−.008	07	−.037	10	.038
41	*RX*	*Vir*	59.6	− 5 13	*K0*	− 41	−.061	18	−.038	18	.072
42	*RW*	*Vir*	12 2.4	− 6 12	*Mb*	+ 06	+.009	05	+.011	04	.014
43	*RY*	*UMa*	15.7	+61 52	*Ma*	− 63	−.045	04	−.007	07	.046
44	*UY*	*Cen*	13 10.7	−44 10	*K5p*	− 12	−.013	07	+.005	08	.014
45	*V*	*CVn*	15.1	+46 04	*Ma*	− 38	−.040	06	−.008	07	.041
46	*S*	*Cham*	21.6	−77 06	*F5*	−.108:	−.367	02	−.121	07	.386
47	*HD*	120400	44.0	−57 05	*G5p*	−.0042	−.031	06	−.019	08	.039
48	*θ*	*Aps*	55.6	−76 09	*Mb*	− 272	−.095	01	−.039	04	.103
49	*RV*	*Boo*	14 35.1	+32 58	*Mb*	+ 13	+.016	08	−.033	10	.037
50	*RW*	*Boo*	37.0	+31 59	*Mb*	− 05	−.006	06	−.012	07	.013
51	*Y*	*Ser*	15 8.8	− 1 31	*Ma*	− 30	−.015	08	−.037	07	.058
52	*R*	*Nor*	28.8	−49 10	*Mb*	− 13	−.013	07	−.048	09	.050
53	*RR*	*CBr*	37.8	+38 53	*Mb*	+ 25	+.029	07	−.034	09	.045
54	*R*	*CBr*	41.4	+28 28	*G0p*	− 01	−.001	04	−.021	03	.021
55	*SX*	*Her*	16 3.2	+25 11	*K2*	− 31	−.042	08	−.030	07	.052
56	*S*	*Oph*	28.5	−16 57	. .	− 13	−.019	17	−.033	14	.038
57	*TX*	*Dra*	33.6	+60 40	*Mb*	− 97	−.072	03	+.014	05	.073
58	*TX*	*Oph*	56.8	+ 5 01	*Com*	− 32	−.048	11	−.040	12	.062
59	*HD*	154676	17 1.8	+ 7 55	*G0*	+ 32	+.047	18	+.001	18	.047
60	*VW*	*Dra*	15.3	+60 46	*K0*	− 50	−.036	02	+.007	03	.037
61	*BM*	*Sco*	31.4	−32 10	*K0*	− 05	−.006	04	+.010	04	.012
62	*AX*	*Sgr*	18 2.6	−18 31	*K5p*	− 09	−.013	18	+.127	18	.128
63	*SS*	*Sct*	38.3	− 7 50	*F8p*	+ 15	+.022	20	+.051	17	.056
64	*R*	*Sct*	42.2	− 5 49	*K0p*	− 36	−.054	04	−.026	04	.060
65	*RT*	*Sct*	44.0	−10 30	*Ma*	+ 06	+.009	16	−.014	18	.017
66	*UX*	*Sgr*	49.1	−16 39	*Mb*	− 17	−.024	21	−.016	25	.029
67	*R*	*Lyr*	52.3	+43 19	*Mb*	+ 23	+.025	02	+.077	02	.081
68	*RX*	*Tel*	59.6	−46 07	*Ma*	+ 13	+.014	08	+.002	09	.014
69	*RY*	*Sgr*	19 10.0	−33 42	*G0p*	± 00	±.000	07	+.006	08	.006
70	*R*	*Sgr*	10.8	−19 29	*Md*	− 05	−.007	13	+.032	12	.033
71	*AF*	*Cyg*	27.2	+45 56	*Mb*	+ 30	+.031	01	+.003	05	.031
72	*S*	*Vul*	41.3	+27 02		− 08	−.011	05	+.000	04	.011
73	*S*	*Cyg*	20 3.1	+57 42		+ 13	+.010	07	+.006	12	.012
74	*R*	*Cap*	5.7	−14 34	. . .	− 02	−.003	16	+.010	12	.010
75	*TZ*	*Aql*	25.0	− 5 06	*Mc*	+ 31	+.016	18	−.010	18	.061

Star			α	δ	Sp.	μ_α	μ_χ	p.e.	μ_δ	p.e.	μ
			h m	° ′		s	″	″	″	″	″
76	*T*	*Cyg*	20 43.2	+34 00	*K*0	+.0036	+.045	±.007	+.010	±.007	.046
77	*AZ*	*Cyg*	54.5	+46 05		− 01	−.004	06	±.000	07	.001
78	μ	*Cep*	21 40.4	+58 19	*Ma*	+ 01	+.001	03	−.002	05	.002
79	*TX*	*Peg*	22 13.4	+13 06		+ 10	+.015	11	−.044	10	.047
80	*RZ*	*Lac*	31.6	+52 15		+ 06	+.006	08	+.023	17	.024
81	β	*Peg*	58.9	+27 32	*Mb*	+ 144	+.188	01	+.138	01	.233
82	*RU*	*Aqa*	23 19.2	−17 52	*Pec*	+ 07	+.010	20	+.008	16	.013
83	*SV*	*Cas*	31.3	+51 12	*Mc*	+ 07	+.007	04	−.010	07	.012
84	*TZ*	*And*	15.8	+46 57	*Mc*	+ 10	+.010	10	+.014	14	.017
85	ρ	*Cas*	49.4	+56 56	*F*8	− 05	−.001	01	+.001	02	.004
86	*V*	*Cep*	54.7	+82 38	*A*	+.0291	+.056	03	+.009	03	.057

The former investigation showed that essentially all the late-type stars with small proper-motions are *giants*, that the solar motion derived from the preferential motion of the stars of late type, exclusive of Class *N*, agreed well with those of the stars of the more common types, and that the motions of the Class *N* stars were to an exceptional degree indeterminate because of their peculiar distribution on the sky. Adding the data contained in Table I, excluding proper-motions in excess of 20″ per century and those of Class *N*, we get as coördinates of the solar motion referred to 300 stars of late type:

$$A = 275°.5 \qquad D = +31°.7 \qquad q = ''.0174$$

From the real motions of the *giant* stars the velocity of the *Sun* in space is 20.7 km. per second.[2,3] From this we derive a mean parallax for these stars, .″00398. Their mean apparent magnitude at maximum is 7.3, and their mean absolute magnitude therefore, +0.3. This value is in close agreement with that determined later for the stars of the separate spectral types by a different method. The added material introduces no essential change in the systematic peculiar motion of these stars. They observe the same tendencies as the stars of the more common spectral types in preferential motion towards Kapteyn's vertex, avoiding the directions perpendicular to the plane of the Milky Way. We may, therefore, apply the same methods as have been applied to the other stars for the determination of their mean distances.

Dependence of Proper-Motion of Probable Error

In two papers[1,4] the writer has called attention to a decrease in average proper-motion with increase in the accuracy of the determinations and to its effect upon the average τ-component, which bids us be cautious in the use of poorly-determined proper-motions for estimations of mean parallax. Yet, in investigations concerning the stars of the rarer spectral types, it frequently happens that much of the data is weak and that if the poorer data be excluded there is very little left. The attempt has, therefore, been made to find some method of minimizing the effect of probable error on the mean proper-motions. This effect is consider-

Table II

DEPENDENCE OF REDUCED PROPER-MOTION ON PROBABLE ERROR

p.e.	$\overline{\overline{<}}$″.007	*	″.007 −″.010	*	″.010 −″.015	*	″.015 −″.025	*	>″.025	*	$\overline{\overline{<}}$″.015	$\overline{\overline{<}}$″.010	logarithmic mean	*
Misc.	″.014	10	″.049	15	″.057	17	″.073	10	....		″.046	″.035	″.031	52
Mabc	.025	23	.031	17	.031	21	.047	16	.057	7	.029	.028	.024	84
Md	.022	23	.035	30	.033	26	.060	26	.086	16	.030	.030	.026	121
R,S,P.	.014	13	.020	13	.061	9	.097	7	.188	9	.024	.017	.021	51
N	.015	31	.025	27	.013	20	.078	7	.186	7	.023	.020	.019	92
All	.019	100	.032	102	.042	93	.065	66	.122	39	.030	.025	.024	100

ably enhanced when the motions are reduced to the mean magnitude of the stars under discussion because, in general, the motions of the fainter stars which are magnified in the process are less well determined than those of the brighter stars which are reduced. Among the stars at present under consideration there is a wide range of magnitude and all the motions have been reduced to magnitude 7.5, the approximate mean. The mean proper-motions $\mu(7.5)$, for several spectral classes and five probable error groups are exhibited in Table II.

The increase in proper-motion with probable error is shown definitely in each group. The same effect appears when the groups are further sub-divided, Ma, Mb, Mc, R, S, $Pec.$, Na and Nb being taken separately. It is obvious that the weighted mean μ cannot, in any case, give adequate representation of the true mean proper-motion; nor can the exclusion of proper-motions with probable errors greater than a given amount accomplish this unless we throw away the greater part of the material. Inasmuch as this effect enters directly into the τ-component, the weighted average τ does not represent the true peculiar stellar motion. In the determination of the mean parallactic motion, q, the effect is largely eliminated by the alternation of signs. The increase of mean μ with the probable error simulates a logarithmic increase, suggesting that the logarithmic mean might represent more closely the true mean μ. In the latter columns of the table are given the results of the combinations of the values of μ by means of the following weights:

p.e.	wt.
$<''.010$	1.0
$''.010 - .015$	0.8
$.015 - .025$	0.5
$> .025$	0.2

On the whole the results in Table II indicate that the weighted logarithmic mean of all the proper-motions probably gives as good, if not a better determination of the mean μ than any other combination of the results. In effect, it eliminates in large part the dependence on the probable error and enables us to use all the data. The relations between the logarithmic means and the means of the proper-motions with probable errors $<''.010$ and $<''.015$ may be well represented by the formula:

$$\text{logarithmic mean } \mu = 0.9\mu \ (\text{p.e.} \leqq''.010)$$
$$= 0.8\mu \ (\text{p.e.} \leqq''.015)$$

In other words if we use only proper-motions with probable errors $<''.010$ or $\leqq''.015$, the mean μ's derived from them should be decreased 10% and 20%, respectively, to represent the true mean proper-motion. From this it follows that the true peculiar motion of any class of stars, when deduced from proper-motions reduced for magnitude, may be represented by the formula:

$$\tau = \text{logarithmic mean } \tau = 0.9\tau \ (\text{p.e.} \leqq''.010)$$
$$= 0.8\tau \ (\text{p.e.} \leqq''015)$$

Mean Parallactic and Peculiar Motion

In Table III are exhibited three sets of computations of the mean peculiar and parallactic motions of the various classes of stars under consideration. The first set is based only upon the proper-motions with probable errors $\leqq''.015$, where those with probable errors between $''.010$ and $''.015$ have received half weight; the second, on all the data, τ being the logarithmic mean; and the third, on the proper-motions of the first set corrected by the systematic corrections suggested by Lewis Boss[12], plus a correction to the proper-motions in declination of the form suggested by Kapteyn[13], $+''.005 \cos \delta$. The form of this correction is probably wrong, but in its effect it is a close approximation to the corrections indicated by recent studies of the systematic errors of the Boss proper-motions in declination. The values of τ in the first and third sets are the actual computed values, without the suggested reduction of 20%. It will be seen that, when these values are so reduced, there is no appreciable disagreement between the values of τ in the three computations. The straight mean of these values so reduced and the logarithmic mean of all the data has been taken to represent the adopted mean peculiar motion for each class, given in the next to the last column. The value of q is in general somewhat smaller for the better material, due in part to the different system of weighting, and is subject to a further slight reduction following the application of the systematic corrections. The differences in the values of q, however, are so small in comparison with the uncertainties in the data that there is no reason for giving one determination preference over another and the adoption of the straight mean of the three as the value of the mean parallactic motion for each class cannot introduce an appreciable error. These values are given in the last column of the table. The striking feature of this tabulation is the essential equality of the values of q for all classes down to and including S, with the rapid decrease through classes R and N.

TABLE III

MEAN PECULIAR AND PARALLACTIC MOTIONS
(Reduced to Magn. 7.5)

Class	p.e. $\overline{\overline{<}}$″.015			All data				corr. pms.		Adopted	
	τ	q	*	τ	q	*	m	τ	q	τ	q
Misc.	″.022	+″.015	11	″.013	+″.013	51	7.9	″.022	+″.011	″.0160	+″.0139
Ma	.006	.020	11	.005	.018	15	6.2	.010	.015	.0059	+ .0174
Mb	.018	.017	24	.012	.018	28	6.4	.016	.015	.0133	+ .0167
Mc	.019	.014	26	.012	.017	41	6.9	.020	.010	.0145	+ .0137
Mabc	.016	.016	61	.010	.018	84	6.6	.016	.014	.0124	+ .0158
Md	.014	.015	89	.011	.016	121	7.1	.017	.011	.0118	+ .0139
Pec.	.015	.013	6	.009	.025	9	8.4	.017	.008	.0113	+ .0151
S	.009	.011	11	.006	.022	11	6.5	.013	.014	.0078	+ .0153
R	.014	.004	16	.014	.018	28	8.4	.017	.006	.0133	+ .0073
Na	.012	.005	16	.009	.006	20	7.4	.011	.007	.0092	+ .0060
Nb	.019	.002	52	.013	.003	62	7.8	.019	− .001	.0111	+ .0013
Np	.011	.000	9	.007	.000	9	7.6	.012	.000	.0083	− .0003

TABLE IV

MEAN PARALLAX AND ABSOLUTE MAGNITUDE

Class	V.	A	π_1	π_2	π_m	M_1	M_2	M_3	A	Adop.
Misc.	15.1	C	+″.0032	″.0050	″.00355	+ 0.25	+ 0.6	+ 0.3	L	+ 0.4
Ma	16.6	C	10	17	352	+ 0.25	+ 0.5		.	+ 0.1
Mb	16.6	C	38	38	381	+ 0.40	+ 0.6	− 0.2	L	+ 0.3
Mc	16.6	C	31	41	331	+ 0.10	+ 0.3			+ 0.2
Mabc	16.6	C	36	34	359	+ 0.30	+ 0.4			+ 0.3
Md	31.:	Me	32	18	291	− 0.20	0.0	+ 0.1	Me	0.0
Pec.	16.6	C	35	32	311	+ 0.15	+ 0.4	. .	.	+ 0.3
S	16.6	C	35	22	324	+ 0.05	+ 0.2	. .	.	+ 0.1
R	26.0	S	17	21	182	− 1.20	− 2.0	− 1.5	S	− 1.6
Na	18.0	Mo	11	21	158	− 1.50	− 1.6	− 1.1	Mo	− 1.4
Nb	18.0	Mo	03	38	100	− 2.50	− 2.2	− 2.4	Mo	− 2.4
Np	18.0	Mo	− .0007	.0022	.00038	− 1.66	− 3.9		.	− 1.2

C, CAMPBELL[5]; L, LUNDMARK and LUYTEN[6], Me, MERRILL[7,8]; Mo, MOORE[9,10]; S, SANFORD[11].

MEAN PARALLAX AND ABSOLUTE MAGNITUDE

Although our ideas of the mean parallactic and peculiar motions of these stars, as derived from the proper-motions, may thus be made fairly definite, the succeeding steps in the determinations of mean parallaxes are subject to a somewhat greater degree of uncertainty, due to the small number of radial velocities available for all classes except *Md*. It seems reasonably certain, however, that practically all these stars are *giants*. The solar speed with reference to the *giant* stars is known to be about 20.7 km. per second[2] with a very small degree of uncertainty. Radial velocities of the stars under discussion are sufficiently numerous to indicate that, in the mean, this value represents closely the solar motion for all classes, except *Md*, for which MERRILL gets −56 km. per second.[7] SANFORD[11] gets 21 km. from the Class *R* stars, rejecting three extremely discordant velocities, and MOORE[9] gets 17.5 km. for Class *N*. For a first approximation it seems sufficiently accurate to adopt for the computation of the mean parallax the value,

20.7 km. The lack of radial velocities has a similar effect on the determination of the mean peculiar motion. This motion was computed from the radial velocities available for each class and was found to agree within the errors due to the scarcity of the data with the peculiar motions of similar classes of the non-variable stars. For this reason we have adopted the peculiar motions derived by CAMPBELL[5] for the late type stars for all classes for which independent determinations have not been made by other investigators. The values used and the authorities are given in the second and third columns of Table IV. The computed parallaxes are given in the fourth and fifth columns. π_1, derived from the parallactic motion, is subject to some uncertainty, from the systematic errors of the proper-motions, uncertainties in the apparent magnitudes and the assumption of the value of the solar motion. These uncertainties, however, are small when compared with those of π_2, derived from the peculiar motion, in which there has been shown to enter a dependence on the probable error, in which the errors in the apparent magnitudes enter with full effect, and in which are involved the errors of the peculiar motions derived from the radial velocities. For these reasons π_1 has been given four times the weight of π_2 in determining the mean parallax of the different classes, π_m, given in the sixth column.

The mean absolute magnitudes have been computed from these parallaxes by means of the formula:

$$M = m + 5 + 5 \log \pi = 12.5 + 5 \log \pi$$

The only additional uncertainty introduced in this process arises from the lack of definite knowledge of the apparent magnitudes. This uncertainty enters in two ways, both of which are systematic but opposite in effect. First, for many of the fainter stars photographic magnitudes only are available. The color indices of these stars are decidedly uncertain and for the reduction to visual magnitude we have used -1.1, the Harvard color index for Class M. The mean effect for most of the stars is under-correction making the mean apparent magnitude too faint. Second, for all the variable stars there arises the question whether we should use the maximum magnitude or the maximum of the mean light curve. The greater part of the magnitudes were taken from the *Revised Draper Catalogue* and are presumably observed maxima. Those not contained in the *Draper Catalogue* are maxima found elsewhere. The use of the maxima of the mean light curves would, in effect, make the mean magnitude fainter than that used. What the combination of the two effects would leave in the way of a systematic error it is impossible to determine except for the Class M stars. Here the first effect must be very small and, due to the second effect, the computed M's are too bright. In the eighth, ninth and tenth columns of the table are given, M_2, the absolute magnitude computed from the better proper-motion data, M_3, absolute magnitudes computed by others, and the authority. The systematic difference between M_1 and M_2 is due largely to the reduction of π by the factor 0.8 in the former case and not in the latter. The computations of LUNDMARK and LUYTEN were based for the most part upon the non-variable stars of Classes F to M, giving evidence that for these classes there is no essential difference in absolute magnitude between the non-variable *giants* and the variables at maximum. For the purposes of further discussion it makes little difference whether we take M_1 or any combination of the three determinations to represent the mean absolute magnitude of these classes of stars. We have taken the straight means which are shown in the last column of the table.

Several points concerning these luminosities are worthy of note. First, in those classes composed wholly of stars whose light is variable, and in general variable through a large range, Misc., stars of F, G and K classes, Ma, b, c, d, $Pec.$ and S, there is a very small range of mean absolute magnitude; they are *giant* stars: and these results in conjunction with those derived elsewhere for the non-variable stars indicate that there is no great range in mean luminosity among the *giant* stars of types ranging all the way from $F5$ to S. Second, the stars of Classes R and N, whose light is either apparently constant or subject to comparatively small variations, are definitely more luminous, a conclusion in harmony with the spectrographic evidence that these stars form a branch of the curve of stellar evolution different from that followed by the K-M stars. Third, in the Class N stars there is evidence of a great range in luminosity following spectral differences in the order, Na, Nb, Np. The difference in mean luminosity between the Na and Nb stars has already been pointed out by MOORE.[10]

The small range in mean luminosity among the *giant* stars, coupled with the comparatively small range in luminosity among the individual *giants* whose parallaxes have been measured, has suggested the possibility of computing the parallaxes of the individual stars from their apparent magnitudes upon the assumption of equal luminosity. Since the proper-motions are in general very small, the parallaxes should in general be independent of proper-motion. To test this assumption parallaxes have been computed for 139 stars of Class M and later for which either

spectroscopic or trigonometric parallaxes were available, using the absolute magnitudes in the last column of Table IV. The comparison of the mean parallaxes is given in Table V.

TABLE V

COMPARISON OF MEAN PARALLAXES

Class	★	*H*	*S*	*L*	*T*
Ma	83	″.012	″.012	. . . .	. . . .
	35	.016	.014	″.015	. . . .
	31	.014	.014	. . . .	″.015
Mb	39	.009	.008	. . . .	. . . .
	9	.014	.010	.011	
	12	.009	.008	. . . .	.015
Mc	5	.007	.007	. . . .	. . . .
Md	7	.009	. . . .	. . . .	.015
	6	.005	. . . .	. .	.007*

*Comparison with VAN MAANEN only.

The column headed *H* gives the parallaxes computed on the assumption of equal luminosity, *S*, the Mount Wilson spectrographic, *L*, the hypothetical parallaxes of LUNDMARK and LUYTEN[6] and *T*, the trigonometric. In the mean the hypothetical parallaxes fit closely the spectrographic and these derived by LUNDMARK and LUYTEN, and possibly the agreement with the trigonometric parallaxes is as good as could be expected from the small number of stars involved. The disagreement in Class *Md* is almost wholly due to a single discordant MCCORMICK parallax, the six others being determinations by VAN MAANEN.

When we come to compare the individual, parallaxes, Table IV, it is found that the agreement with the spectroscopic and for the most part with the trigonometric values is satisfactory for all stars fainter than Magn. 2.0. The assumption of equal luminosity appears to hold, therefore, for the stars fainter than Magn. 2.0, but for the two bright *Ma* stars, *α Orionis*, Magn. 0.9, and *α Scorpii*, Magn. 1.2, it appears to break down. Nor is this surprising, as these stars are known to be *super-giants*, their diameters having been measured with the interferometer. It is certain that stars of this category are exceedingly few, wherefore it seems a reasonably safe proposition, for investigations in which great accuracy is not required, to assume that the parallaxes of the *giant* stars, i.e., presumably those with small proper-motions, of Class *M* at least, may be computed from their apparent magnitudes. While we have made no direct comparisons of the parallaxes of the *F5* to *K giants*, nor of the *Pec.* and *S*-type stars for which no spectroscopic or trigo-

TABLE VI

COMPARISON OF INDIVIDUAL PARALLAXES

	★	*m*	*H*	*S*	*T*	*A*
			Ma			
1	31	4.9	″.012	″.010	″.017	*A*
2	259	2.4	.038	.042	.051	*A*, *Mc*
3	582	5.0	.009	.009	.015	*Ma*
4	691	2.8	.032	.026	.014	*A*, *Mc*
5	1014	6.3	.006	.008	.001	*Ma*
6	1128	5.8	.008	.009	.001	*Mc*
7	1154	5.7	.008	.009	.009	*Ma*
8	1468	0.9	.076	.012	.022	*A*, *Mc*, *Y*
9	1549	6.3	.006	.008	.003	*Ma*
10	1501	3.7	.021	.014	.013	*A*, *Mc*
11	1599	5.2	.010	.009	−.005	*Mc*
12	1604	3.2	.026	.016	.020	*A*, *Ma*, *Mc*
13	C824	6.9	.005	.005	.008	*A*, *J*
14	1868	5.9	.008	.006	.008	*Ma*
15	2049	5.3	.010	.010	.018	*S*
16	2378	6.3	.006	.008	.000	*Ma*, *Mc*
17	2800	5.7	.008	.012	.005	*Ma*
18	2921	6.2	.007	.009	.051	*Ma*, *Mc*
19	3031	4.1	.017	.017	.024	*A*, *Mc*
20	3089	4.2	.017	.016	.010	*A*
21	3367	3.7	.021	.021	.016	*A*, *Mc*
22	3581	6.0	.007	.009	.012	*Ma*
23	4054	5.3	.009	.011	.033	*Ma*
24	4135	3.0	.029	.029	.044	*Mc*
25	4188	5.4	.010	.007	.016	*Mc*
26	4193	1.2	.066	.017	.029	*Mc*
27	4976	4.6	.014	.013	.010	*A*, *Mc*
28	5052	3.8	.020	.019	.006	*A*, *Mc*
29	5409	6.0	.007	.007	.009	*Ma*
30	5593	4.0	.018	.014	.012	*A*
31	5940	2.6	.035	.030	.025	*A*, *Mc*, *Y*
32	5952	4.7	.013	.013	.001	*A*
33	6127	5.2	.010	.011	.016	*A*
			Mb			
34	161	5.6	.009	.009	.014	*Ma*
35	217	6.3	.006	.009	−.001	*Ma*
36	660	5.9	.008	.006	.011	*Ma*
37	698	3.7	.021	.013	.033	*Mc*
38	1256	5.9	.008	. .	.007	*Ma*
39	1846	5.7	.008	.008	.002	*Ma*, *Mc*
40	2020	5.8	.008	.006	.006	*Ma*
41	2245	5.8	.008	.008	.029	*Ma*
42	3398	5.9	.008	.007	.043	*Ma*
43	3861	6.0	.007	.007	.005	*Ma*
44	4262	5.8	.008	.010	.022	*Ma*
45	4343	6.8	.005	.005	.009	*Ma*

	★	m	H	S	T	A
			Mc			
46	2915	6.0	.007	.005	−.001	*Ma*
47	3100	5.1	.009	.009		
48	1125	6.0	.007	.006		
49	1630	6.1	.006	.007		
50	5125	5.6	.008	.010		
			Md			
51	W 5	6.7	.005		.029	*Ma*
52	530	2.5	.032		.065	*Mc*
53	W 7*a*	6.5	.005		.007	*Ma*
54	W 81	6.0	.006		.001	*Ma*
55	W 120	6.1	.005		.012	*Ma*
56	W 11*a*	6.1	.006		−.008	*Ma*
57	W 163	6.5	.005		.002	*Ma*
			Na			
58	1676	5.9	.003		.005	*Ma*
			Nb			
59	3322	5.5	.003		.000	*Ma*

In column 2 the numbers unaccompanied by a letter designate the number of the star in Boss' *Preliminary General Catalogue*; C refers to *Publications of the Cincinnati Observatory*, No. 18; and W refers to the writers list of proper-motions in *Astronomical Journal*, No 814, the added letter designating the second list.

The authorities quoted in the last column are: *A*, Allegheny; *J*, Jost; *Ma*, van Maanen; *Mc*, McCormick; *S*, Swarthmore; and *Y*, Yerkes.

Where there is more than one determination of the trigonometric parallax, the separate values are given below in the order in which the authorities are quoted above.

★	π			★	π		
2	″.010,	″.062		18	″.080,	″.022	
4	.006,	.024		19	.030,	.017	
8	.020,	.017,	″.030	21	.020,	.012	
10	.023,	.003		27	.021,	−.001	
12	.037,	.009,	.015	28	−.005,	.017	
13	.012,	−.004		31	.025,	−.001,	″.050
16	.001,	−.001		39	.010,	−.007	

nometric parallaxes are available, the assumption of equal luminosity amongst these stars does not seem unreasonable. The wide range in mean luminosity in the *R* and *N* groups, however, makes any similar assumption with regard to them extremely hazardous. The close agreement of the computed values with the parallaxes measured by van Maanen was to be expected as the parallaxes of all these stars must be extremely small.

Conclusions

1. Proper-motions are presented for 86 variable stars not included in earlier lists.

2. With reference to the long-period variable stars, exclusive of Class *N*, the *Sun* is moving towards the point at R. A. 275°.5; Dec., +31°.7, with a speed of 1″.74 per century.

3. The dependence of the reduced proper and peculiar motions upon the errors in their determinations may be eliminated in large part by the use of the logarithmic mean.

4. The mean parallactic motions of the long-period variables of Classes *F*5 to *S*, inclusive, are essentially equal, a rapid decrease being evidenced in Classes *R* and *N*.

5. The absolute magnitudes of the variables of Classes *F*5 to *S* are also essentially equal, while the stars of Classes *R* and *N* are definitely more luminous, maximum mean brightness being reached by the stars classified as *Np*.

6. Upon the assumption of equal luminosity among the stars of small proper-motion in the Classes *F*5 to *S*, the distances of the individual stars may be computed with a fair degree of certainty. The wide range in mean luminosity in Classes *R* and *N* makes any estimation of the distances of the individual stars upon the assumption of equal luminosity within the class-division decidedly uncertain.

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THE PROPER-MOTION OF BARNARD'S STAR IN *OPHIUCHUS*,

DETERMINED BY PHOTOGRAPHY WITH THE 26-INCH McCORMICK REFRACTOR,

By HAROLD L. ALDEN.

Schlesinger has shown in the *Astronomical Journal* 30, 75, 1916 that the rapidly moving star in *Ophiuchus* discovered by Barnard in 1916 is one of the few stars for which the secular change in the proper-motion is sufficiently large that it may be detected within a short interval of time. Using provisional values of the parallax, proper-motion, and radial velocity, he computed an increase of 0″.0005 per year in the total proper-motion.

In the *Publications of the Astronomical Society of the Pacific* 34, 126, 1922, Lundmark and Luyten give the results of a discussion of all the published data for this star. They find for the position of the star referred to the equator and equinox of 1900.0: —

$$\text{Right Ascension}\quad 17^h\,52^m\,56^s.767 \quad -0^s.0467t$$
$$\pm .0024 \quad \pm .00014$$

$$\text{Declination}\quad +4^\circ\,25'\,8''.56 \quad +10''.250t \quad -0''.00070t^2$$
$$\pm .084 \quad \pm .0088 \quad \pm .00022$$

The probable error of each of the quantities is given beneath it.

No secular term in right ascension was computed. The coefficient of the quadratic term in declination is three times its probable error. It is however, of the opposite sign to that predicted by Schlesinger. The negative sign can be accounted for only by a positive radial velocity or by errors of observation. The latter seems the more logical explanation since the large velocities of approach obtained for this star at the Lick and Mount Wilson Observatories are in substantial agreement. In fact, Lundmark and Luyten point out the dependence of this term on the early meridian circle observation of Lamont in 1842, which might be affected by sufficient error to account for the secular term.

Photographs of this star were taken with the McCormick refractor soon after its discovery. Enough time has now elapsed so that duplicate plates provide a good determination of the average proper-motion of the star in the interval. Three pairs of plates have been measured, each plate containing two twelve minute exposures. Data concerning these plates is given in Table 1. The plates were measured on the Gaertner screw machine in both direct and reverse positions for each coördinate. They were oriented by means of a trail on plate 2729. As the correction to the 1900 equator is less than one-tenth of a degree it has been neglected. It will have no effect on the total motion. One millimeter on the plates is equal to 20″.760.

TABLE 1

Plate	Date	G.M.T. of mid-exposure	Hour angle	Observer	Quality
		h m	h		
2729	1916 June 18	17 46	+0.4	Mitchell	fg
3860	1917 April 7	21 41	−0.1	Lamb	g
3861	1917 April 7	22 5	0.0	Lamb	fg
14103	1923 April 6	21 19	−0.9	Alden	g
14104	1923 April 6	21 43	−0.5	Alden	g
14555	1923 June 18	17 47	+0.4	Alden	g

Twenty comparison stars were used for the determination of the plate constants. These were well distributed over the plates and ranged in brightness from 7.0 to 11.3, the mean photovisual magnitude being 10.0. The photovisual magnitude of the proper-motion star determined from three plates is 9.3. None of the comparison stars showed conspicuous relative motion, the mean residuals in right ascension being ±0″.014 and in declination ±0″.013. The relative motion of B.D. +4° 3560 is +0″.002 in right ascension and −0″.013 in declination. This star was used by

BARNARD for micrometer observations of the proper-motion star and is designated as 'a' by him in the *Astronomical Journal* 29, 181, 1916.

The relative proper-motion of BARNARD's star as derived from the separate pairs of plates is given in Table II. Corrections have been applied to the first two pairs of plates for differential parallax.

TABLE II

Plates	Interval Years	Mean Date	Relative Proper-motion R.A.	Relative Proper-motion Decl.
			″	″
14103 3860	5.9957	1920.265	−0.6987	+10.2648
14104 3861	5.9957	1920.265	−0.7076	+10.2479
14555 2729	6.9978	1919.963	−0.7022	+10.2586
Weighted mean		1920.154	−0.7029	+10.2572
Probable error			±0.0017	± 0.0032

Assuming that the solar apex referred to stars of the tenth magnitude is at R. A. $18^h\ 0^m$ and Decl. $+30°$ and that the mean secular parallax of the comparison stars is $0''.0135$, the parallactic motion of the comparison stars is $-0''.0004$ in right ascension and $-0''.0058$ in declination. These quantities must be added to the relative motion to give the absolute motion. The resulting values for the absolute proper-motion of BARNARD's star at the mean epoch 1920.154, referred to the equator of 1916.5, are

$$\mu\alpha\ cos\ \delta = -0''.7033 \qquad \mu\delta = +10''.2514$$
$$\mu\alpha = -0^s.04703$$

The total motion is $10''.276$ in the position angle $356°.07$.

The total proper-motion for 1900 obtained by LUNDMARK and LUYTEN is $10''.274$ per year. Assuming this to be the best value at that date, the motion derived above for 1920 suggests a secular change in the proper-motion of $+0''.0001$ per year. The probable errors of the quantities are such that little significance can be attached to this result, but it argues against the reality of the negative term found by LUNDMARK and LUYTEN.

McCormick Observatory, University of Virginia, November, 1923.

OBSERVATIONS OF ASTEROIDS AT THE YERKES OBSERVATORY,

BY G. VAN BIESBROECK AND O. STRUVE.

(Second Series.)

The work on faint asteroids started with the 24-inch reflector in 1922 has been continued along the line described in *A. J.* 822. As far as the weather has permitted we have made exposures for all objects fainter than $13^m.8$ that require further observations as indicated in the "Oppositions Ephemeriden 1923". No special search was made for new objects. We followed only those that happened to be found on the regular exposures. The measures are again divided in two parts: the first refers to known objects; approximate positions for 1925.0 and the corresponding corrections to the ephemerides for 1923 will be found for each object. A list of those that could not be found in the computed position is appended. As previously stated the field covers a radius of about 50′. The second part contains accurate measures of the new asteroids announced in *A. J.* 822 and of some additional ones found this year.

KNOWN ASTEROIDS

	1923		1925.0				Corr.	
			h m s	° ′	M		m	′
106 *Dione*	June	4.763	16 3 10	−21 6.9	11.8	VB	+0.6	− 2
	June	8.714	16 0 33	−21 1.6	11.6	VB	+0.6	− 2
	June	11.672	15 58 21	−20 58.2	11.6	VB	+0.5	− 2
228 *Agathe*	Jan.	18.752	8 12 35	+20 57.9	15.7	S	+1.9	− 9
	Jan.	20.758	8 10 12	+21 2.5	15.8	S	+1.9	− 9
	Jan.	21.795	8 5 17	+21 13.4	..	S	+1.7	−10
383 *Janina*	May	6.751	13 49 4	− 7 55.3	15.4	S	−1.8	+ 8
	May	7.738	13 48 25	− 7 49.1	15.3	VB	−1.8	+10

KNOWN ASTEROIDS (*Continued*)

	1923	1925.0 h m s	° '	M		Corr. m	
406 *Erna*	Mar. 16.780	11 19 43	+ 0 37.8	15.4	VB	−0.9	+ 7
540 *Rosamunde*	Apr. 8.685	11 13 41	+ 1 18.7	13.1	S	−0.1	+ 4
614 *Pia*	July 16.786	20 56 37	− 6 7.7	14.8	VB	−1.3	− 4
	July 17.772	20 55 54	− 6 9.1	14.7	VB	−1.3	− 4
620 *Drakonia*	Feb. 22.797	9 7 4	+24 33.5	15.1	VB	−2.4	+ 8
	Feb. 24.873	9 5 8	+24 31.8	15.0	S	−2.5	+ 8
664 *Judith*	Jan. 18.683	7 6 33	+12 1.9	15.2	S	−0.2	0
	Jan. 20.736	7 5 0	+12 7.6	15.6	S	−0.2	0
666 *Desdemona*	Apr. 8.751	11 34 15	− 3 41.0	15.9	S	−0.6	+ 4
778 (1914 UA)	Aug. 14.844	21 51 6	−13 6.7	14.3	VB	+0.7	+ 9
	Aug. 16.761	21 49 28	−13 9.7	14.0	S	+0.8	+ 9
	Aug. 18.801	21 47 12	−13 12.4	14.2	VB	+0.8	+10
814 *Tauris*	May 4.617	13 3 54	+21 35.5	14.4	VB	0.0	0
	May 7.758	13 2 8	+21 30.0	14.6	VB	−1.0	0
867 *Kovacia*	May 12.714	13 46 19	− 9 0.6	15.8	S	−0.6	+ 3
	May 13.672	13 45 43	− 8 59.0	16.0	S	−0.6	+ 4
901 *Brunsia*	Jan. 12.910	7 23 50	+19 37.5	15.0	VB	+2.2	− 8
	Jan. 15.778	7 20 28	+19 41.2	14.7	VB	+2.1	− 8
	Jan. 18.710	7 17 5	+19 44.8	15.1	S	+2.1	− 8
	Jan. 22.843	7 12 34	+19 49.7	14.6	VB	+2.0	− 7
915 (1918 b)	Apr. 13.745	12 39 55	− 5 31.8	14.6	VB	−0.4	+ 1
	Apr. 18.696	12 35 20	− 5 12.8	14.8	VB	−0.3	+ 2
934 (1920 HK)	Apr. 11.730	12 17 37	−18 22.3	14.8	VB	0.0	+ 1
943 (1920 HX)	May 12.835	16 10 50	− 6 37.4	14.5	S	−0.1	0
	May 13.845	16 10 4	− 6 36.0	14.9	S	0.0	0
956 (1921 IW)	Jan. 20.795	8 7 51	+11 13.5	16.0	S	−0.9	+ 3
	Jan. 22.844	8 5 41	+11 21.6	16.1	VB	−0.9	+ 3
959 (1921 KF)	Jan. 24.848	8 16 53	+25 41.7	14.2	S	+2.7	− 3
972 (1922 LK)	Apr. 8.651	10 45 34	− 2 32.5	15.4	S	+1.4	+25
	Apr. 11.681	10 41 26	− 2 18.3	15.3	VB	+1.5	+28

MISSING ASTEROIDS

No.	Date	No.	Date	No.	Date
157	June 8	646	Mar. 4	946	July 13
299	May 9	692	June 4	960	Mar. 16
421	May 12	721	June 8	961	Jan. 18
430	Apr. 13	748	June 20	962	Jan. 18
502	Aug. 14	822	May 13	963	Apr. 18
525	Apr. 8	870	Jan. 18	964	Feb. 22
553	July 16	878	Aug. 6	967	Apr. 8
555	Apr. 18	883	May 5	969	Apr. 8
561	July 8	935	July 16	970	Apr. 11
603	May 21	936	Mar. 13		
641	July 8	941	May 13		
643	May 5	942	Apr. 18		

NEW ASTEROIDS

1922 NB (Y. O. 1.) S

1922	1922.0 h m s	° ' "	M
Oct. 25.75764	2 0 38.98	+10 30 16.5	15.0
Nov. 16.65451	1 44 48.95	9 19 35.8	15.1
Dec. 9.54861	1 36 57.40	8 55 5.2	16.2
1923	1923.0		
Feb. 15.55226	2 13 12.16	13 1 42.7	16.6
Feb. 15.58142	2 13 13.83	+13 1 50.9	

1922 NC (Y. O. 2.) S

1922	1922.0		
Nov. 14.80486	1 46 41.76	+ 9 39 6.7	15.7
Nov. 16.65451	1 45 28.63	9 42 21.4	16.0
Nov. 20.70417	1 43 9.46	9 50 38.0	15.7
Nov. 22.74792	1 42 10.15	+ 9 55 32.6	16.0

1922 ND (Y. O. 3.) S

1922		1922.0		
		h m s	° ′ ″	M
Nov.	20.68820	1 12 9.57	+ 9 15 11.3	15.9
Nov.	20.70117	1 12 9.10	9 15 36.0	
Dec.	15.61180	1 35 17.52	8 11 21.6	16.1
Dec.	20.66771	1 36 2.16	8 6 37.3	
1923		1923.0		
Feb.	3.51255	1 58 32.79	9 11 11.5	16.4
Feb.	4.56941	1 59 24.57	+ 9 15 21.1	16.4

For elements see *Lick Observatory Bulletin*, No. 347.

1922 NE (Y. O. 4.) VB

1922		1922.0		
Nov.	23.83612	4 30 56.94	+36 28 49.3	16.0
Nov.	24.76890	4 29 54.11	36 30 52.7	15.8
Nov.	28.86667	4 25 18.12	36 38 17.2	15.8
Dec.	1.96286	4 21 18.77	36 41 56.2	15.9
Dec.	9.62764	4 13 21.88	36 44 35.1	16.0
Dec.	15.80139	4 7 0.17	36 39 50.1	16.4
Dec.	22.73796	4 0 45.42	+36 30 33.1	15.8

1922 MZ (Y. O. 5.) VB

1922		1922.0		
Nov.	23.82170	4 37 6.85	+36 37 46.9	15.2
Nov.	23.83342	4 37 5.86	36 37 49.8	
Nov.	24.76890	4 36 0.20	36 37 17.2	15.3
Dec.	15.82569	4 12 10.93	35 18 27.4	15.0
Dec.	15.84028	4 12 10.20	35 18 26.0	
Dec.	22.68657	4 6 16.33	35 17 26.4	15.4
Dec.	22.70735	4 6 15.58	+35 17 20.3	
1923				
Mar.	10.56583	4 42 12.57	31 16 21.0	
Mar.	10.59535	4 42 14.90	31 16 17.0	16.7

Preliminary orbit, *Lick Observatory Bulletin*, No. 347.

1922 MY (Y. O. 6.) VB

1922		1922.0		
Nov.	21.78348	4 32 26.48	+37 6 31.6	
Nov.	28.86667	4 27 21.68	37 0 6.3	16.2
Dec.	1.96286	4 23 29.04	36 52 8.4	16.2
Dec.	9.62764	4 11 11.75	36 22 14.9	16.0
Dec.	15.80139	4 7 29.65	35 49 9.6	16.1
Dec.	22.70735	4 1 22.71	+35 5 16.7	16.2

1923 NJ (Y. O. 7.) VB

1923		1923.0		
		h m s	° ′ ″	M
Jan.	12.91012	7 21 5.81	+19 29 58.9	14.8
Jan.	15.79121	7 18 24.96	19 35 58.2	14.5
Feb.	4.67778	7 2 40.72	20 14 0.2	14.2
Feb.	15.74045	6 57 33.46	20 30 26.3	14.2
Apr.	8.60333	7 15 54.54	+20 44 29.6	15.7

1923 NK (Y. O. 8.) S

1923		1923.0		
Jan.	20.75752	8 9 17.89	+20 16 39.5	13.9
Jan.	24.79479	8 5 37.39	20 19 20.6	13.8
Feb.	20.61019	7 45 7.36	20 23 36.2	14.1
Mar.	7.70613	7 39 12.41	20 13 38.2	13.6
Mar.	20.71788	7 38 5.55	19 58 36.9	
Apr.	17.68817	7 47 1.61	19 6 31.7	
Apr.	18.64169	7 47 32.59	+19 4 16.4	13.9

(Y. O. 9.) VB

1923		1923.0		
June	1.77593	16 3 49.01	−21 13 49.0	15.4
June	7.77685	16 1 33.20	21 8 28.3	15.3
June	8.71394	16 0 51.35	21 6 41.8	15.2
June	12.74835	15 57 57.86	20 59 15.7	15.4
June	15.74115	15 55 51.54	20 52 42.3	15.5
June	19.73668	15 53 21.62	20 45 43.0	
July	6.66530	15 46 3.26	20 24 26.5	15.3
July	12.66552	15 44 55.98	20 20 58.4	15.3
July	16.63021	15 44 36.94	20 20 0.2	15.2
July	17.67164	15 44 35.35	20 19 57.0	15.3
Aug.	2.62314	15 47 7.63	−20 28 2.4	15.3

The motion corresponds to that of (300) *Geraldina*, but the identity seems doubtful on account of the brightness, which is 3^{M} fainter.

(Y. O. 10.) VB

1923		1925.0		
Aug.	14.844	21 51 7	−12 46.0	15.8
Aug.	16.761	21 49 3	−12 50.8	15.5
Aug.	18.801	21 46 51	12 55.8	15.7
Aug.	21.821	21 43 39	−13 3.0	15.7

Williams Bay (Wisconsin),
Aug. 27, 1923.

MINOR PLANET 1922 *ND*,

SPECIAL PERTURBATIONS ARISING FROM THE ACTION OF *Jupiter*,

By C. J. MERFIELD, F. R. A. S.

In the determination of the perturbations, here presented, the method of *variation of parameters* has been used. Only the perturbations depending on the first powers of the disturbing forces have been taken into account.

The orbit elements, adopted as a basis of the work, are published in the *Lick Observatory Bulletin*, No. 347, and were calculated by C. D. Shane and Mary Lea Shane. An examination of the residuals indicates that these orbit elements are good ones, and in every way suitable for the requirements of this calculation.

Throughout the work the equinox 1922 has been used for the preparation of the data necessary, and the epoch 1922, December 21, selected as the date of the adopted osculating orbit elements.

Osculating Orbit Elements

Epoch 1922 Dec. 21.0 G.M.N.

$M = 213^\circ\ 46'\ 12''.0$

$\left.\begin{array}{l}\pi = 192\ \ 19\ \ 47\ .0 \\ \Omega = 213\ \ 10\ \ 48\ .0 \\ \iota = \ \ 10\ \ 47\ \ \ 8\ .0\end{array}\right\}\ 1922$

$\varphi = \ \ 4\ \ 55\ \ 54\ .7$

$\mu = 672''.7070$

$\text{Log}\ a = 0.4814537$

PERTURBATIONS

Minor Planet 1922 *ND*

Equinox 1922

Julian Day	δM	$\delta\pi$	$\delta\Omega$	$\delta\iota$	$\delta\varphi$	$\delta\mu$
	″	″	″	″	″	″
242 3410	+ 0.0	− 0.0	+ 0.0	+ 0.0	− 0.0	−0.0000
3442	12.9	− 22.9	0.1	0.1	−16.0	−0.0416
3474	35.1	− 54.3	0.1	0.1	−19.6	−0.0827
3506	66.2	− 96.7	+ 0.1	0.1	−28.8	−0.1231
3538	105.4	− 148.2	− 0.1	+ 0.0	−37.1	−0.1630
3570	151.9	− 208.0	− 0.4	− 0.1	−45.3	−0.2022
3602	204.4	− 274.8	− 0.8	− 0.2	−52.4	−0.2405
3634	261.9	− 347.3	− 1.5	− 0.3	−58.7	−0.2778
3666	322.6	− 424.0	− 2.3	− 0.5	−64.1	−0.3140
3698	385.1	− 503.2	− 3.4	− 0.6	−68.4	−0.3488
3730	447.7	− 583.0	− 4.7	− 0.7	−71.9	−0.3822
3762	508.6	− 661.6	− 6.2	− 0.9	−74.4	−0.4139
3794	565.9	− 736.9	− 7.9	− 1.0	−76.0	−0.4439
3826	617.9	− 807.2	− 9.8	− 1.0	−76.6	−0.4719
3858	663.0	− 870.8	− 11.8	− 1.1	−76.3	−0.4976
3890	699.9	− 925.7	− 13.9	− 1.1	−75.4	−0.5209
3922	727.2	− 971.1	− 16.1	− 1.0	−73.9	−0.5416
3954	743.3	−1005.1	− 18.3	− 0.9	−72.0	−0.5595
3986	748.5	−1028.5	− 20.4	− 0.8	−69.9	−0.5744
4018	742.3	−1039.8	− 22.4	− 0.6	−67.8	−0.5864
4050	725.8	−1040.3	− 24.2	− 0.4	−65.9	−0.5956
4082	699.3	−1030.2	− 25.7	− 0.1	−64.3	−0.6014
4114	664.7	−1011.3	− 27.0	+ 0.2	−63.0	−0.6050
4146	623.0	− 981.7	− 27.9	0.4	−62.9	−0.6058
4178	576.8	− 952.3	− 28.6	0.6	−63.2	−0.6052
4210	529.3	− 915.8	− 28.9	0.8	−63.4	−0.6032
4242	478.9	− 875.8	− 29.1	0.9	−63.9	−0.6020
4274	425.1	− 833.8	− 29.0	0.9	−64.7	−0.6017
4306	366.8	− 787.6	− 29.1	0.7	−65.4	−0.6045
4338	301.6	− 737.1	− 29.3	+ 0.3	−65.7	−0.6126
4370	231.8	− 676.5	− 30.2	− 0.2	−65.3	−0.6286
4402	144.8	− 602.5	− 31.9	− 1.0	−63.8	−0.6547
4434	+ 32.2	− 501.4	− 35.0	− 2.1	−61.1	−0.6952
4466	− 114.3	− 371.6	− 40.1	− 3.1	−56.8	−0.7528
4498	− 311.8	− 197.2	− 47.8	− 5.1	−51.1	−0.8339

Julian Day	δM	$\delta\pi$	$\delta\Omega$	$\delta\iota$	$\delta\varphi$	$\delta\mu$
	″	″	″	″	″	″
242 4530	− 574.0	+ 40.6	− 58.8	− 6.9	−43.9	−0.9425
4562	− 921.0	359.9	− 74.4	− 8.9	−36.2	−1.0858
4594	−1381.3	779.0	− 94.6	−11.1	−28.2	−1.2702
4626	−1972.6	1322.0	−121.4	−13.2	−21.9	−1.5048
4658	−2723.2	2012.0	−155.6	−15.1	−18.3	−1.7977
4690	−3658.0	2870.7	−198.2	−16.7	−20.6	−2.1597
4722	−4803.1	3921.0	−250.1	−17.6	−31.1	−2.6020
4754	−6179.9	5181.6	−312.4	−17.4	−53.8	−3.1320
242 4786	−7828.1	+6687.0	−385.2	−16.0	−92.4	−3.7666

EPHEMERIS

Greenwich Midnight

Date		α app.	δ app.	Log Δ	Log r
		h m s	° ′ ″		
1923 Dec.	11.5	7 30 31.33	7 30 58.8	0.33428	0.47808
	13.5	7 29 25.11	7 25 12.7	0.33096	0.47784
	15.5	7 28 14.17	7 19 54.5	0.32782	0.47759
	17.5	7 26 58.79	7 15 4.2	0.32485	0.47734
	19.5	7 25 39.22	7 10 42.7	0.32207	0.47710
	21.5	7 24 15.71	7 6 50.9	0.31949	0.47685
	23.5	7 22 48.58	7 3 29.2	0.31710	0.47661
	25.5	7 21 18.12	7 0 38.0	0.31492	0.47636
	27.5	7 19 44.70	6 58 17.9	0.31296	0.47612
	29.5	7 18 8.65	6 56 29.4	0.31122	0.47587
	31.5	7 16 30.37	6 55 12.9	0.30972	0.47562
1924 Jan.	2.5	7 14 50.22	6 54 28.3	0.30845	0.47538
	4.5	7 13 8.69	6 54 17.4	0.30743	0.47513
	6.5	7 11 26.24	6 54 36.6	0.30665	0.47489
8	8.5	7 9 43.38	6 55 26.7	0.30612	0.47464
	10.5	7 8 0.50	6 56 47.8	0.30584	0.47440
	12.5	7 6 18.10	6 58 38.8	0.30581	0.47415
	14.5	7 4 36.69	6 59 59.1	0.30603	0.47390
	16.5	7 2 56.67	7 3 47.6	0.30649	0.47366
	18.5	7 1 18.46	7 7 3.7	0.30720	0.47341
	20.5	6 59 42.47	7 10 46.0	0.30814	0.47317
	22.5	6 58 9.15	7 14 53.4	0.30931	0.47292
	24.5	6 56 38.82	7 19 24.7	0.31071	0.47268
	26.5	6 55 11.84	7 24 18.4	0.31234	0.47233
	28.5	6 53 48.54	7 29 33.5	0.31417	0.47219

Osculating Orbit Elements

Equinox Epoch	1924 1924 Jan. 9.0	1925 1925 April 17.0	1926 1926 July 25.0
	° ′ ″	° ′ ″	° ′ ″
M	285 40 57.4	12 21 20.0	97 36 0.5
π	192 9 10.6	192 8 2.5	193 28 28.9
Ω	213 12 23.9	213 12 54.4	213 10 5.0
ι	10 47 6.3	10 47 7.8	10 46 48.9
φ	4 54 38.7	4 54 50.1	4 55 23.6
μ	672″.2631	672″.1054	670″.1050
Log a	0 .4816419	0 .4817127	0 .4825758

The epochs are for Greenwich Mean Noon on the dates given. These are also the dates of the osculation elements. These epochs have been selected at or about the time of the opposition of the planet.

The opposition of the year 1925 will be the most favorable one, as the planet arrives at perihelion on February 8 of this year.

Equatorial Co-ordinates

$x = r \sin a \sin (A + v)$.

$y = r \sin b \sin (B + v)$.

$z = r \sin c \sin (C + v)$.

AUXILIARIES

Equinox	1924	1925	1926
Log sin a	9.9977073	9.9977061	9.9977141
Log sin b	9.9863001	9.9862993	9.9862997
Log sin c	9.4275903	9.4276155	9.4275000
	° ′ ″	° ′ ″	° ′ ″
A	281 41 15.5	281 41 3.8	283 0 33.0
B	190 10 52.0	190 10 38.7	191 30 17.5
C	213 27 21.6	213 27 26.7	214 41 55.0

APPENDIX

When preparing an ephemeris of a celestial object from elliptical orbit elements, the general procedure is to find "E", the eccentric anomaly, from the well known equation.

$$M = E - e \sin E \quad \ldots\ldots\ldots\ldots\ldots \quad 1$$

The true anomaly and radius vector may now be found from, say

$$\left.\begin{aligned} \sqrt{r}\sin\frac{v}{2} &= \sin\frac{E}{2}\sqrt{a\;(1+e)} \\ \sqrt{r}\cos\frac{v}{2} &= \cos\frac{E}{2}\sqrt{a\;(1-e)} \end{aligned}\right\} \quad \ldots\ldots\ldots \quad 2$$

In the preparation of the ephemeris here given, the solution of (1) and (2) are avoided in the following manner.

We have

$$M = \int \frac{r^2}{a^2}\frac{dv}{\sqrt{1-e^2}} \;. \qquad \frac{r}{a} = \frac{1-e^2}{1+e\cos v}$$

therefore

$$M = (1-e^2)^{\frac{3}{2}} \int_0^v \frac{dv}{(1+e\cos v)^2} \quad \ldots\ldots\ldots \quad 3$$

The solution of this integral can be easily obtained. After reduction and transformation we have

$$M = \sin^{-1}\frac{\sin v\;\sqrt{1-e^2}}{e(1/e+\cos v)} - [5.3144251]\frac{\sin v\;\sqrt{1-e^2}}{(1/e+\cos v)} \quad 4$$

$$r = \frac{a(1-e^2)}{e(1/e+\cos v)} \;.$$

These forms have been selected for ease in computation.

With the argument "v," at suitable intervals, taken between the limits required, prepare a table of "M," from equation (4), then the values of the true anomaly can be readily interpolated for the arguments required.

If the value of "E" be required for any purpose, its value may be determined from the equation.

$$\sin E = \frac{\sin v\;\sqrt{1-e^2}}{1+e\cos v} \;.$$

The method of finding the true anomaly and radius vector, here outlined, will be found expeditious in practice.

It has been used by the writer in this connection for some time past with much success.

The Melbourne Observatory, South Yarra, Victoria, 1923, October 25.

THE SOLAR ECLIPSE OF SEPTEMBER 10, 1923,

OBSERVED AT THE U. S. NAVAL OBSERVATORY, WASHINGTON, D. C.,

By F. B. LITTELL.

[Communicated by Rear Admiral W. D. MacDougall, U. S. Navy, Superintendent.]

The times of first and last contacts were observed visually with four equatorially mounted telescopes. Mr. Bower used a polarizing eyepiece, and recorded his times on a chronograph. The other visual observers used diagonal eyepieces, and observed by the eye and ear method.

Time of first contact was also determined photographically from 4 plates exposed on the 40-foot photoheliograph. Trees in the line of sight prevented the observation of the last contact with this instrument. The times of the exposures were automaticaly recorded on a chronograph.

The zenith distance of the sun was 59°.2 for first and 80°.3 for last contact. The predicted times, corrected in accordance with the data in *A. J.* No. 827, were $3^h\ 41^m\ 3^s.6$ for first, and $5^h\ 32^m\ 33^s.0$ for last contact.

Mr. C. B. Watts assisted in the photographic observations and in their reduction. Mr. G. M. Raynsford counted time.

The following are the results, 75th meridian time,

First Contact

Observer	Instrument	Time	Observer's notes
J. C. Hammond	5-inch Equatorial	3^h 11^m 5.	A few seconds late.
G. A. Hill	5-inch Equatorial	11 8.	
H. E. Burton	5-inch Equatorial	11 3.	Seeing good.
E. C. Bower	12-inch Equatorial	11 5.7	Seeing poor. Late 8ˢ.
G. H. Peters	Photoheliograph	11 3.9	
	Photoheliograph	10 54.6	
	Photoheliograph	11 2.7	
	Photoheliograph	10 56.9	

Last Contact

Observer	Instrument	Time	Observer's notes
J. C. Hammond	5-inch Equatorial	5^h 32^m 31.	Seeing poor.
G. A. Hill	5-inch Equatorial	32 21.	
H. E. Burton	5-inch Equatorial	32 31.	Seeing poor. Perhaps a little late.
E. C. Bower	12-inch Equatorial	32 31.2	Seeing poor. Uncertain 3^s.

EPHEMERIS OF COMET (DUBIAGO-BERNARD),

By FRANK E. SEAGRAVE.

The ephemeris is based upon elements copied from a recent number of *Nature*. The name of the computer of the elements was not given. During the present month and during January the comet will be far south in declination. It will be nearest to the *Earth* in April. The ephemeris is correct only in so far as the elements are.

Elements

T = 1923 Nov. 17.70 G. M. T.
ω = 254° 32′ 0″
π = 333 4 0
Ω = 227 36 0
i = 65 43 0
log q = 9.89760
Motion = retrograde

Ephemeris

1924 Gch. Midnight		α	δ	$Log\ r$	$Log\ \Delta$
		h m s	° ′ ″		
Feb.	1	17 28 56	−34 32 58	0.19424	0.30432
	9	17 27 4	−32 39 17	0.22362	0.29706
	17	17 23 25	−30 41 43	0.25102	0.28656
	25	17 17 40	−28 36 40	0.27668	0.27357
Mar.	4	17 9 34	−26 20 29	0.30070	0.25885
	12	16 58 49	−23 49 35	0.32324	0.24362
	20	16 45 19	−21 0 35	0.34448	0.22945
	28	16 29 11	−17 52 12	0.36454	0.21828
Apr.	5	16 10 42	−14 26 31	0.38348	0.21213
	13	15 50 56	−10 50 42	0.40144	0.21301

Boston, Mass.,
December 6, 1923.

ERRATA, *A. J.* NO. 830,

By GEO. VAN BIESBROECK.

Dr. S. Nicholson calls my attention to a mistake in the position of Satellite VIII of *Jupiter* on 1923, June 16. The corrected value is:

$11^h\ 29^m\ 10^s.90,\qquad -11°\ 35'\ 43''.1\qquad (1923.0)$

Yerkes Observatory,
December 13, 1923.

CONTENTS

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A COMPARISON OF THE AVERAGE VELOCITY OF BINARIES WITH THAT OF SINGLE STARS,

By J. H. OORT.

It has recently been suggested that some kind of equipartition of energy may exist in our stellar system, the earlier type stars having at the same time greater masses and lower velocities than those of later spectrum.[1] Moreover, the existence of a correlation between mass and velocity within the same spectral-type has been made probable by the fact that there seems to be a relation between absolute magnitude and average velocity. In this connection it seems interesting to inquire whether or not a difference in velocity exists between double stars and single stars.

It is possible to prove that, within each spectral-type, the visual binaries have nearly twice the mass of single stars. PANNEKOEK[2] has shown that a close correlation exists between the mass and the ratio of spectroscopic parallax to trigonometric parallax, in the sense that stars with large masses give high values of this ratio. From the list of binaries used in the present paper, I took the stars for which spectroscopic as well as trigonometric parallaxes are given in *Mount Wilson Contributions*, No. 199, and I compared the two parallaxes for the brighter components. Stars for which the trigonometric parallaxes are founded only on older and inaccurate results have been omitted.

As the spectroscopic parallaxes have been made to agree with the trigonometric ones for a material principally consisting of single stars, it is evident that any systematic difference in mass between brighter components of binaries and single stars of the same absolute magnitude will be borne out by the above comparison.

The computed average ratios between the spectroscopic parallax of the brighter component and the trigonometric parallax are given below; four stars in which one of the parallaxes is larger than 0″.200 were excluded.

Spectrum	Mean ratio	Number of stars
F	0.90	43
G	1.10	27
K	1.07	14
All	0.99	84

The conclusion seems justified that there is no appreciable difference in mass between the brighter components of double stars and single stars of the same absolute magnitude. It is true that part of these stars may have been selected on account of large orbital motion so that there might be a slight selection of more massive stars. This objection may be removed by excluding from the eighty-four stars all those occurring in JACKSON and FURNER's list of binaries with appreciable orbital motion.[3] The total mean ratio then becomes 1.05 (57 stars).

Knowing the mean mass of the brighter components we can form an estimate of the mass of the whole system with the help of the relation between mass and luminosity recently published by HERTZSPRUNG.[4]

For the material used in what follows the mean magnitude differences between the two components are about 2.0 for the *A*- and *F*- type stars, and 2.8 for the *G* and *K* stars. From HERTZSPRUNG's formula (1):

$$m + 5 \log p = -\frac{\log \text{Mass}}{0.084}$$

we find the corresponding ratios of the mass of the fainter component to that of the brighter one as 0.68 and 0.58 respectively. (For the *G* and *K* stars with later type companions, used on page 141, the mass ratio is 0.79.) Therefore, in comparing the average velocities of double stars with those of single stars

[1] See, for instance, HALM, *Monthly Notices*, 71, 634, 1911, and SEARES, *Mount Wilson Contributions* No. 226, 1921.

[2] *Bulletin of the Astronomical Institutes of the Netherlands*, No. 19, 1922.

[3] *Monthly Notices R. A. S.*, 81, 30, 1920.

[4] *Bull. Astr. Neth.* No. 43 1923.

having the same absolute magnitude as the brighter components of the double stars, the average mass of the former will be about 1.7 or 1.6 times that of the latter stars. Some uncertainty remains, however, as the above mass ratios were found from a material consisting wholly of dwarf stars, whereas the stars considered in the following investigation are, in considerable part, absolutely bright stars.

A list of double stars with known radial velocities was selected from a manuscript *Catalogue of Bright Stars* prepared by DR. SCHLESINGER. This catalogue contains all the stars of the *Revised Harvard Photometry*, and among other information contains notes about double stars and all radial velocities published up to June, 1923. Very nearly all stars from BURNHAM'S and INNES' catalogues have been noted in the *Bright Star Catalogue*, unless the difference in magnitude between the two components is unusually large.

I took all pairs of spectra A, F, G and K in which the magnitude difference is smaller than 6.0, excluding those in which the companion is at the same time fainter than the 9th magnitude and more than 30″ distant from the main star (unless a common motion shows that they are physically connected). It is easy to prove that the percentage of optical doubles among the remaining stars is too small to have any influence on the results. The B-type stars were omitted because of the large number of moving clusters among them, which will tend to obscure every difference in mean velocity between two groups of stars as the same cluster velocities are added to both. Part of the same difficulty holds for the A-type stars.

In order to avoid all possible influences that might make the double-star velocities too large I made sure that the material is complete and is not affected by the selection of large common motions; this was done by taking only the Northern pairs with combined magnitude brighter than 5.9 and the Southern pairs brighter than 5.0 from the list mentioned above.

The average absolute magnitude of the brighter components of the double stars with spectra F, G and K was computed with the help of spectroscopic parallaxes in the following way. Spectroscopic absolute magnitudes have been determined for about two-thirds of the stars, for the remaining binaries I computed the average proper motion and apparent magnitude and selected from the binaries with known absolute magnitude a set having the same average proper motion and magnitude. The mean absolute magnitude of these stars was then accepted as that of the binaries with unknown parallaxes. The total means of the absolute magnitudes thus computed are given in column 3 of table 1. Nearly all the G and K binaries used are *giants*, only 11 being found to be fainter than absolute magnitude +3.0.

The material used to compare single stars with the binaries consists exclusively of stars with known spectroscopic parallaxes thus making it possible to exclude stars within certain limits of absolute magnitude in order to get the same average absolute magnitude as the brighter components of the binaries. This was effected by excluding all stars brighter than +1.0 in the spectral class F, 50 percent of the stars brighter than 0.0 in class G, and all stars brighter than 0.0 in class K (see table 1, column 5, for the average absolute magnitudes). The recent Mount Wilson radial velocities[5] have not been included in the case of the single stars. All stars fainter than 6.5 apparent magnitude have been excluded.

The average radial velocities freed from solar motion (accepting a velocity of 20 km, apex $18^h\ 0^m$; $+30°$) are compared in the following table.

Table 1

Spectrum of brighter component	Double Stars, brighter than $5^m.9$ for + declinations and brighter than $5^m.0$ for − declinations		Single Stars, brighter than $6^m.5$.	
	Aver. vel.	Abs. magn.	Aver. vel.	Abs. magn.
$A0-A9$	10.4 km (67)	.....	11.0 km (177)	.....
$F0-F9$	15.3 km (52)	$+2^M.5$	14.6 km (89)	$+2^M.7$
$G0-G9$	11.2 km (26)	+1 .7	15.8 km (88)	+1 .8
$K0-K9$	12.8 km (38)	+1 .0	15.0 km (254)	+1 .2

The number of stars on which the averages rest are given between brackets.

A few remarks may accompany the table:

For the spectral class A no effort has been made to equalize the absolute magnitudes of double and single stars, and the average velocity for the latter is that given by CAMPBELL.[6]

In the fourth column all doubles with magnitude differences smaller than 6.0 have been excluded.

For a binary the radial velocity of the brighter star has been used throughout, but the difference from that of the center of gravity must be so small that it cannot have any influence on the results.

All stars with peculiar radial velocities of 50 km or higher have been excluded from the comparison for two reasons. In the first place there are indications that the stars with space velocities higher than 66 km

[5] *Mount Wilson Contributions*, No. 258, 1923.

[6] *Lick Observatory Bulletin*, 6, 127, 1911.

form a group by themselves and can be sharply distinguished from the rest of the stars;[7] their velocities may have arisen from a different cause and they should not, therefore, be mixed with the ordinary stars if we want to determine the connection between velocity and mass or velocity and absolute magnitude. In the second place the omission of a few stars with exceptional velocities will increase the accuracy of our results and in this case the gain will be greater than the loss due to the decrease of the differences in mean velocity between two groups of stars.

The binaries are grouped according to the spectrum of the brighter component as in the great majority of cases this is the only one known. No attention was paid to stream-motion, the average distance from the vertices being supposed approximately the same in both cases. It appears from the table, that for the spectra A and F there does not seem to be any difference between the two average velocities although the binaries have a mass 1.7 times that of the single stars with which they are compared.

For the G and K stars the binaries seem to have lower velocities. This result can, however, be interpreted in different ways. PROFESSOR HERTZSPRUNG has drawn my attention to the fact that a relatively high percentage of the G and K double stars have B or A companions and that it might be questioned whether these stars should not have been classified among the B- and A-type stars. To investigate this point I made a list of all G and K stars that are known to have B- or A-type companions, a total of 42 stars. After the exclusion of the high velocity star o^2 *Eridani* there are 16 stars[8] with known radial velocities, giving a mean peculiar velocity of 7.2 km. The same exceptionally low velocity is obtained from the proper motions of these stars: considering only the 24 stars for which proper motions occur in Boss's Catalogue we get an average secular parallax of $0''.036$ and an average proper motion in a direction at right angles to the great circle through the apex (average τ-component) of $0''.015$; accordingly the average linear velocity in that direction is 8.3 km. Correcting for a probable error of $0''.005$ in the proper motions, this value becomes 7.8 km.

As far as the evidence from this small number of stars goes it looks as though these stars with blue companions should according to their velocities be classified among types A and B rather than among types G and K, although the G and K stars are 2.5 magnitudes brighter than their companions on the average, this value being found from the 17 binaries in which the brighter component is brighter than apparent magnitude 6.0.[9]

This becomes the more surprising by the fact that in practically all binaries, visual as well as spectroscopic, where the mass-ratio is known, the brighter star has the largest mass.[10]

It is not only in their motions, but also in their positions relative to the galaxy that these later type binaries more closely resemble B- and A-type stars than stars of the spectrum of their brighter components, as shown in table 2.[11] The first four lines of the table give the percentage of all stars of the 6th magnitude between 0° and ±20°, ±20° and ±40°, ±40° and ±90° galactic latitude respectively. They were computed from table 11, *Groningen Publications* No. 30, for apparent magnitude 6.0, which is the average magnitude of the 41 binaries mentioned above. The last two lines give the corresponding percentages for these binaries; the last line, in which only stars with Northern declination are used, is added to show that the strong galactic condensation cannot be explained by a selection in the observing program.

Table 2

Spectrum	Percentage of stars between galactic latitudes 0° and ±20°	±20° and ±40°	±40° and ±90°	Number of stars
$B0-B9$	67%	24%	9%	917
$A0-A9$	49	26	25	1343
$G0-G9$	41	29	30	671
$K0-K9$	41	28	31	1425
Binaries	66	29	5	41
Northern declinations only	64	29	7	28
Area Unit 10.000 sq. degrees	1.41	1.24	1.47	4.13

[7]See *Bull. Astr. Neth.* No. 23, 1922.

[8]Including one *Ma* star having a blue companion, namely α *Scorpii*.

[9]So far as I know there is within this limit only one binary in which the brightness of the G or K component is less than that of the A or B component.

[10]It should be mentioned, however, that PANNEKOEK, in estimating the mass-ratio of three binaries where the fainter companion was of earlier spectral type, came to the conclusion that in all three cases the fainter star was the most massive (*Bull. Astr. Neth.*, No. 19, page 117.)

[11]PERRINE, in *Astrophysical Journal* 47, 293, noticed that these stars show a decided preference for the galaxy.

The total numbers of stars used in each line is given in the last column.

The binaries show a galactic condensation practically as strong as that of B stars of the same apparent magnitude. This is not a perspective effect arising from the large average distance of these absolutely bright stars (for the most distant *single* K giants exhibit hardly any preference for the galaxy), but it shows that their *linear* distance from the galactic plane is on the average very much smaller than that of single K stars.[12]

That this erroneous classification of the G and K stars with blue companions may well account for the differences in the two last lines of table 1 appears plausible if we remark that in 37% of the cases in which the spectrum of the companion has been determined it appears to be of Class A or B. If we consider only those pairs in which the spectrum of the companion is known to be later than $A9$ we find 26 G and K stars with an average velocity of 15.8 km.[13] while the average velocity of single stars of the same absolute magnitude and spectrum is 16.7 km (79 stars).

For the stars about which we are sure as to the spectrum according to which they should be classified the ratios of the mean velocity of single stars to that of binaries (with the approximate probable errors) come out as follows:

A stars	1.06 ±0.07
F stars	0.95 ±0.09
G and K stars	1.06 ±0.12

The average is 1.02 ±0.05 (p.e.) whereas the factor expected in the case of equipartition would be 1.27.[14]

The material used is almost too scant to permit any conclusions, but, so far as the indications go, it seems that there is no appreciable difference between the two average velocities, and that therefore if a kind of equipartition does exist among stars of different mass then binary stars must somehow have been affected just as though the mass of the system were equal to that of the more massive component alone. It would also follow that the motions of the stars have not been influenced to a considerable extent by transfer of energy from one star to another, as this transfer would have resulted in higher velocities for the single stars than for the binaries. It would be of interest to get more information about radial velocities of a homogeneous list of double stars; for instance, all BURNHAM stars brighter than apparent magnitude 8.0 in which the components differ by less than three magnitudes and are far enough apart to allow color determinations of both components.

In the above note I have dealt with visual binaries only, because in the case of spectroscopic binaries a comparison of the mass of the systems with that of single stars could not well be made. It may, however, be of interest to add a preliminary comparison for these binaries as in this case again there does not seem to be any difference in mean velocity.

In order to avoid a larger difference in mean magnitude between the two groups of stars compared, the average velocities computed by CAMPBELL (*loc. cit.*) were used for the single stars, and in the case of the spectroscopic binaries I took only stars brighter than 5.5 apparent magnitude.

The mean velocities, with the number of stars between brackets, are given in table 3. Stars with velocities higher than 50 km. and a few stars for which the velocity of the center of gravity is uncertain, have been excluded. The average probable error of the velocities of the binaries considered is not larger than that of CAMPBELL's velocities.

Table 3

Spectrum	Spectrosc. Bin. brighter than $5^m.5$	Single Stars (CAMPBELL)
$B0$–$B9$	6.6 km (43)	6.5 km (225)
$A0$–$A9$	12.0 km (30)	11.0 km (177)
$F0$–$F9$	12.4 km (20)	14.1 km (184)
$G0$–$K9$	16.0 km (18)	13.6 km (492)

The ratio of the average radial velocity of the single stars to that of the binaries is in this case 1.03 ±0.05 (p.e.).

Summary:

Evidence has been brought forward that the average mass of the brighter component of a visual binary is about equal to that of a single star of the same spectrum and absolute brightness.

There are no indications of a difference in mean velocity between single stars and binaries (both visual and spectroscopic), but for the spectra G and K the material is insufficient for any definite conclusion.

It seems probable that the G- and K-type binaries with blue companions should, according to their motions as well as to their galactic condensation, be classified among the spectra B and A rather than among G and K.

Yale University Observatory,
December 5, 1925.

[12] The same characteristics: low velocity and strong condensation towards the Galaxy; are shown by the so-called c-stars, and it may be that we are dealing with this kind of star here. It must be observed, however, that even the spectroscopically brightest K giants do not show a galactic condensation comparable with that of the binaries.

[13] If we take only the brighter stars, as was done for table 2 (to avoid possible selection for large proper motion) there remain 14 stars with an average velocity of 16.6 km.

[14] In the computation of this theoretical factor account has been taken of the fact that velocities higher than 50 km were excluded, which, supposing a Gaussian distribution in the velocities, diminishes the factor from 1.30 to 1.27.

WIRELESS LONGITUDE DETERMINATIONS OF THE U. S. COAST AND GEODETIC SURVEY,

By GEORGE D. COWIE.

During the past two seasons, 1922 and 1923, a field party of the U. S. Coast and Geodetic Survey, under charge of the writer, has been using the wireless time signals sent from the U. S. Naval Observatory via the Annapolis (NSS) radio station in the determination of longitudes. The stations occupied are in Wisconsin, Colorado, New Mexico, Washington, and Southeast Alaska. The results are so satisfactory that it seems certain that the radio method has superseded the wire and cable method.

A special radio receiving set with a three stage radio frequency amplifier and a radio recorder were designed for this work by Drs. Eckhardt and Karcher of the U. S. Bureau of Standards. The antenna consists of six wires, spaced about eighteen inches apart, one-hundred twenty feet long and supported between two 42-foot sectional poles. This set combines lightness, portability, and simplicity, and the graphic recording of the radio time signals. The time of star transits, the radio time signals, and the seconds of the local chronometer are all inked on a chronograph sheet by a single recording pen.

In use the set is first tuned with a telephone headset and then the amplified radio current is switched into a high-resistance relay, the armature of which makes and breaks the chronograph pen circuit with the incoming time signal. The chronograph pen is also in circuit with a siderial break-circuit chronometer. A complete record of both the chronometer breaks and the time signals is assured by means of a double winding on the pen magnet so arranged that if the pen is held over by a radio time signal it will be released when the chronometer circuit is broken.

The transit-micrometer of a Bamberg broken-telescope astronomic transit is switched in circuit in place of the radio relay when star observations are being made for local siderial time at the occupied station. This eliminates the effect of any fluctuation in the mechanical operation of the pen magnet from the accuracy of the final result, as any fluctuation is common to all functions. Fluctuations in the chronometer relay circuit also have no effect on the accuracy of the final result as the time reference points are the instants that the pen beings to move due to the chronometer breaks, and both the star transits and radio time are referred to these instants.

In the determination of longitude differences by wireless the errors are those due to the observational errors in the time determinations at the U. S. Naval Observatory and at the Coast and Geodetic Survey field station, which, probably, are less than 0.02 sec. on any night at either place, and to the error in the adopted value of the lag of the transmitting and receiving circuit for the time-signal or in the fluctuation of this lag.

The value of the lag was determined before the 1922 season and again before the 1923 season in the following manner: The field astronomical equipment was set up on a concrete pier on the Naval Observatory grounds and the difference of longitude between this pier and the center of the clock room was determined as in the field, using the same radio receiving outfit.

The discrepancies between the differences determined by star observations and the Annapolis time signals and the difference determined by direct linear measurement between the pier and the clock room gave the values of the lag combined with the personal equation of the Coast and Geodetic Survey observer and any other systematic error.

The observations in 1922 on eight nights, gave a mean value of the lag of -0.025 ± 0.005 sec., and the observations in 1923 on five nights gave a mean value of -0.040 ± 0.009. A mean adopted value of -0.033 ± 0.010 was therefore used for the work of both seasons.

Fluctuations in the lag are caused by the change in the time of mechanical operation of the local relays in the time circuit at the Naval Observatory, in the relays at Annapolis through which the time signals are received via the land line of the Western Union Telegraph Company and transmitted to the antenna, and in the radio relay of the field recorder.

These fluctuations are assumed to be small, of the order of 0.005 sec., as frequent checks on a part of the circuit are measured at the Naval Observatory and care is taken in the field to keep the tension of the relay armature springs constant.

In addition to the wireless longitude work observations were made for latitude, azimuth and gravity at each of the stations in Southeastern Alaska. The azimuth and longitude results combined furnish the additional data necessary to permit the adjustment of the complete precise triangulation from the southern boundary, Dixon Entrance, to the vicinity of Skagway, a distance of 350 miles. This adjustment has been delayed until the wireless time signals offered a means of making the longitude determinations. The triangulation is a part of the international scheme, agreed to by the U. S. Coast and Geodetic Survey and the

Canadian Geodetic Survey, to carry precise horizontal control, based on the Standard North American Datum, from Puget Sound, through British Columbia, Southeast Alaska, and Yukon Territory to Western Alaska.

The following data taken from the field computation show the residuals for each night of longitude determination in the field. The third column gives the residuals before the U. S. Naval Observatory clock corrections had been applied; and the fourth column, the residuals after these corrections had been applied. The probable errors in the last column are derived from the residuals in the fourth column.

Season of 1922

Date	Station	Before applying clock corrections	After applying clock corrections	Probable error
1922		Sec.	Sec.	Sec.
Aug. 30	La Lande,	−0.020	0.000	
Sept. 13	N. Mex.	+0.012	−0.016	
16		−0.030	−0.018	
20		+0.036	+0.034	±0.008
Sept. 27	Artesia,	+0.032	+0.005	
30	N. Mex.	−0.006	−0.035	
Oct. 1		−0.032	−0.002	
2		+0.007	+0.031	±0.009
Oct. 9	Des Moines,	−0.047	0.000	
10	N. Mex.	−0.095	−0.013	
11		+0.062	+0.008	
15		+0.079	+0.006	±0.003
Oct. 22	Las Animas,	+0.097	+0.012	
23	Colo.	−0.077	−0.028	
24		−0.047	−0.026	
25		+0.029	+0.042	±0.011
Note: Above are checked computations				
June 20	Wisconsin	−0.056	−0.007	
21	Rapids, Wis.	+0.015	−0.003	
22		+0.025	+0.023	
23		+0.017	−0.015	±0.005
July 1	Ladysmith,	+0.006	+0.001	
2	Wis.	−0.034	−0.004	
8		+0.155	+0.061	
12		−0.126	−0.059	±0.016
July 20	Rhinelander,	−0.074	−0.051	
22	Wis.	+0.020	−0.015	
24		−0.007	0.000	
25		+0.062	+0.064	±0.016

Season of 1923

Date	Station	Before applying clock corrections	After applying clock corrections	Probable error
1923		Sec.	Sec.	Sec.
May 24	Percy Islands,	+0.017	+0.005	
25	Alaska	−0.045	−0.015	
June 1		+0.028	+0.010	±0.005
June 13	Ship Island,	+0.054	+0.027	
20	Alaska	+0.019	+0.010	
28		−0.074	−0.037	±0.013
July 14	Sukoi Island,	+0.014	−0.022	
23	Alaska	−0.057	−0.045	
27		+0.022	+0.011	
28		+0.021	+0.057	±0.015
Aug. 5	Eldred Rock,	−0.028	−0.026	
6	Alaska	−0.010	+0.004	
8		+0.038	+0.022	±0.009
Aug. 16	Young's	+0.003	+0.010	
17	Point, Alaska	−0.028	−0.028	
18		+0.026	+0.019	±0.009
Aug. 25	Astley Point,	+0.050	+0.015	
26	Alaska	−0.056	−0.045	
Sept. 4		+0.006	+0.030	±0.015
Sept. 10	Quiet Harbor, Alaska	−0.002	−0.019	
11	(10 p.m. W.T.)	+0.042	+0.052	
12	(4 a.m. W.T.)	−0.039	−0.033	±0.017
Oct. 9	Alki Point,	−0.015	+0.021	
12	Wash.	+0.008	−0.017	
13		+0.006	−0.005	±0.007

During the 1922 season instructions called for observations on four nights for a longtitude determination as the accuracy of radio recording was still unproven. During the 1923 season only three nights were required, conforming with the practise of the Survey for wire determinations during the past ten years.

In both seasons the Bamberg broken-telescope portable transit, equipped with the transit micrometer, was used at the field stations. For speed and con-

venience in setting up, use was made of a collapsible aluminum tripod, firmly set in the ground or on the rocks and made rigid by the use of turnbuckles on the diagonal members. The observing program for a night consisted of observations on from 10 to 12 stars arranged in two sets with the time signal received between the two.

As indicated by the probable errors, the accuracy of results obtained by the use of radio time signals is about equal to that obtained by the wire-telegraphic method. It is to be remarked however that the computation of the work at only four of the above-listed stations has been checked and incidentally that the average probable error at these four stations is only ±0.008 sec. The average probable error for all the stations in the table is ±0.011 sec. The average for wire-telegraphic determinations since 1914 is about ±0.012 sec.

In spite of the possibility of a small constant error being introduced by an error in the adopted value of the lag, the advantages of the wireless method outweigh the disadvantages.

The wireless method allows stations to be occupied which are remote from telegraph and cable stations, thus affording a better selection of stations in a triangulation system; it requires only one field party instead of two for a determination, thereby cutting the cost of operations and obviating the necessity of waiting for clear weather to occur simultaneously at two field stations; and, finally, it refers each difference of longtitude directly to the longitude of the clock room of the U. S. Naval Observatory at Washington, thus avoiding the possibility of accumulation of error incident to chains of longitude differences.

U. S. Coast and Geodetic Survey, Washington, D. C.,
December 8, 1923.

FORTY-SEVEN NEW DOUBLE STARS,

By BERNHARD H. DAWSON.

The forty-seven double stars of the accompanying list were found with the 433mm refractor of La Plata Observatory. The numbers are continued from *Publicaciones del Observatorio de La Plata* Tomo IV. Only the mean results are given here; the individual measures will be published in some future volume of the same series. I am indebted to Dr. Innes for collating this list with his catalogue.

No.	C.P.D.	R.A.	1900 Decl.	1900+	Angle	Distance	Magn.	Nights
	°	h m s	° ′		°	″		
112	−36 8	0 4 38	−36 49	22.18	170.2	0.74	9.7 10.3	3
113	−36 21	0 9 40	−36 43	22.18	275.7	1.00	10.4 10.4	3
114	−28 78	0 56 26	−28 20	21.92	290.2	1.10	9.5 13.2	2
115	−51 271	2 1 1	−50 57	22.03	40.4	1.36	9.3 9.4	3
116	−34 610	5 8 58	−34 36	21.65	153.8	0.82	8.8 9.3	3
117	−34 647	5 17 40	−34 26	22.03	6.6	2.24	6.4 11.8	3
118	−34 694	5 33 0	−34 47	21.98	206.4	0.37	8.4 8.7	3
119	−28 1234	6 14 40	−28 19	22.18	200.5	3.99	9.4 10.5	3
120	−29 1250	6 19 35	−29 58	23.25	87.7	0.51	8.9 9.1	3
121	−29 1276	6 22 30	−29 4	23.29	219.4	4.34	9.6 10.2	2
122	−28 1416	6 39 2	−28 56	22.07	142.7	3.18	9.8 10.6	3
123	−45 1202	7 3 7	−45 7	23.24	178.7	0.74	9.7 10.3	3
124	−30 1595	7 12 46	−30 32	22.95	308.9	4.78	9.3 13.6	3
125	−33 1433	7 16 42	−33 22	22.89	49.9	2.10	8.8 11.2	3
126	−33 1441	7 17 50	−33 26	22.89	265.1	1.73	10.5 1.11	3
127	−33 1459	7 20 3	−33 17	22.89	14.0	1.73	9.1 11.6	3.2
128	−33 1465	7 20 28	−33 56	23.36	255.9	0.97	9.1 11.5	2
129	−31 1537	7 20 54	−31 37	22.88	309.1	2.17	5.8 11.5	3
130	−33 1492	7 23 45	−33 36	23.36	169.1	1.14	10.1 10.5	2
131	−29 2950	9 10 48	−29 57	23.18	122.8	1.06	8.3 10.5	3

No.	C.P.D.	R.A.	1900 Decl.	1900+	Angle	Distance	Magn.	Nights
		h m s	° ′		°	″		
132	−35 1640	11 1 38	−35 12	22.33	122.2	2.42	9.1 11.6	3.2
133	−34 1505	11 1 4	−34 20	22.98	221.1	1.35	8.7 13.8	3
134	−29 3535	11 44 22	−29 28	22.29	196.3	0.95	9.4 11.9	3
135	−29 3562	11 55 18	−29 47	23.35	54.8	3.27	7.6 12.5	3 2
136	−29 3574	11 58 18	−29 52	23.36	268.3	2.44	9.4 12.5	2
137	−29 3573	11 58 51	−30 4	23.36	86.8	2.35	8.6 12.5	2
138	−28 4133	12 10 51	−29 4	23.34	320.6	1.44	8.0 12.0	1
139	−34 5482	12 20 49	−34 18	22.31	348.4	2.36	10.2 11.9	2
140	−37 5349	12 39 18	−37 35	22.65	17.9	1.98	9.4 10.6	3
141	−29 3886	13 53 14	−29 40	23.23	148.7	2.01	7.9 14.5	1
142	−28 4966	14 24 50	−29 7	23.23	127.3	1.14	9.8 10.0	1
143	−28 5132	15 23 23	−28 30	23.28	5.1	1.02	8.5 14.5	2
144	−29 4230	15 32 3	−29 39	23.32	306.4	1.26	9.5 13.0	1
145	−39 6898	16 3 23	−39 52	22.21	145.2	2.69	7.0 12.2	4
146	−41 7500	16 24 44	−41 36	21.84	130.9	8.64	5.5 13.1	3
147	−34 6932	17 32 31	−34 52	22.27	30.0	2.90	10.5 12.4	3
148	−35 7104	17 33 54	−35 36	22.27	140.2	1.46	8.4 10.5	3
149	−36 7524	17 36 54	−36 9	22.27	60.3	1.79	9.5 10.5	3
150	−29 5858	18 59 3	−29 7	22.72	68.6	2.14	9.4 13.4	2
151	−28 6768	18 59 36	−28 28	22.72	345.2	2.48	9.9 11.2	2
152	−28 7200	20 17 19	−28 46	22.77	293.2	2.87	9.6 10.2	2
153	−28 7393	21 3 1	−28 52	22.43	280.4	3.70	7.2 13.7	3
154	−29 6534	21 11 2	−29 1	22.46	84.7	1.57	9.6 10.0	3
155	−32 6440	21 34 35	−31 54	22.74	226.1	2.42	10.1 10.3	3
156	−34 9062	22 4 43	−34 19	22.86	298.3	1.32	7.7 13.7	3
157	−35 9288	22 36 42	−35 42	22.84	292.4	2.25	9.7 12.1	3
158	−35 9456	23 47 17	−35 12	22.18	326.4	0.57	9.3 11.4	3

NOTES: Nos. 128, 130, 136, 137, 138, 141, 142, 143, 144 will receive further measures at the earliest opportunity. Principal star noted yellow in Nos. 121, 125; orange, 129; red, 150. Δ47 is *AC* of δ129; Δ202 is *AC* of δ146.

ELEMENTS OF ASTEROID (1922 *W* 20).

BY FRANK E. SEAGRAVE.

E = 1923 Feb. 8.5021 G. M. T.

M = 344° 39′ 49″.51	φ = 22° 28′ 42″.37
ω = 253 23 59 .49	$\log a$ = 0.4177058
π = 152 41 32 .76	$\log q$ = 0.2085528
☊ = 259 17 33 .57	μ = 838″.3934
i = 25 8 43 .77	P = 1545.813 days

These elements are based on three positions (Dec. 22, 1922, Feb. 8, 1923 and Mar. 24, 1923), published by GEO. H. PETERS of the U. S. Naval Observatory in *A. J.* 882. This asteroid has been identified as the lost WATSON asteroid (132) *Aethra* by LUTHER of Dusseldorf. (See *Astronomische Nachrichten*, 5241, 1923.)

Boston, Mass., Feb. 11, 1924.

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OBSERVATIONS OF ASTEROIDS,

MADE WITH THE PHOTOGRAPHIC TELESCOPE OF THE U. S. NAVAL OBSERVATORY,

By GEORGE H. PETERS.

[Communicated by CAPTAIN EDWIN T. POLLOCK, U. S. Navy, Superintendent.]

Name	Mag.	Date	G.M.T.	Astrographic 1925.0 α	δ	O — C α	δ
			h m	h m s	° ′ ″	m	″
163 *Erigone*	10.3	Jan. 4	15 04.5	* 5 28 26.05	+14 30 28.2	−7.2	− 7
163 *Erigone*	10.3	Jan. 6	14 29.1	5 27 01.87	+14 36 33.4	−7.2	− 7
402 *Chloë*	10.3	Jan. 6	15 18.0	5 39 57.92	+11 40 26.9	+0.3	+ 9
415 *Palatia*	9.7	Jan. 6	16 11.0	6 03 28.90	+15 43 42.9	+2.6	+ 12
402 *Chloë*	10.3	Jan. 7	14 59.9	5 39 07.65	+11 46 40.5	+0.3	+ 9
415 *Palatia*	9.7	Jan. 7	15 45.9	6 02 45.86	+15 50 41.6	+2.6	+ 12
886 *Washingtonia*	14.1	Jan. 24	15 19.5	* 9 19 17.27	+37 51 44.3	−0.8	0
886 *Washingtonia*	14.1	Jan. 27	15 25.5	9 16 31.65	+38 07 32.0	−0.8	0
886 *Washingtonia*	14.1	Jan. 31	15 46.5	* 9 12 43.32	+38 26 29.3	−0.8	0
487 *Venetia*	12.2	June 28	15 33.0	16 46 39.62	−13 29 27.2	+1.0	− 6
487 *Venetia*	12.2	June 29	14 59.4	16 45 54.74	−13 32 14.1	+1.0	− 6
308 *Polyxo*	10.8	July 1	15 10.7	16 33 58.32	−15 23 02.9	−0.8	0
308 *Polyxo*	10.8	July 2	14 35.0	16 33 25.32	−15 22 59.4	−0.8	0
16 *Psyche*	9.3	July 25	16 25.4	20 36 20.19	−16 27 05.3	+1.9	+ 5
277 *Elvira*	12.5	Sept. 24	15 35.8	0 16 33.76	+ 3 18 32.7	−3.8	− 24
787 *Moskva*	12.3	Sept. 24	15 35.8	0 28 06.77	+ 2 41 53.4	+1.0	0
277 *Elvira*	12.5	Sept. 25	16 00.4	0 15 46.05	+ 3 13 07.8	−3.8	− 24
787 *Moskva*	12.3	Sept. 25	16 00.4	0 27 22.47	+ 2 28 33.9	+1.0	0
277 *Elvira*	12.5	Sept. 26	16 00.0	* 0 14 59.30	+ 3 07 45.4	−3.8	− 24
787 *Moskva*	12.3	Sept. 26	16 00.0	0 26 38.52	+ 2 15 29.5	+0.9	0
787 *Moskva*	12.3	Sept. 27	16 08.3	0 25 54.18	+ 2 02 19.7	+0.9	− 1
536 *Merapi*	11.3	Sept. 27	17 27.8	2 06 53.78	− 6 42 18.6	−0.6	+ 6
787 *Moskva*	12.3	Sept. 28	16 05.0	0 25 10.06	+ 1 49 16.5	+0.9	− 1
277 *Elvira*	12.5	Sept. 29	15 52.0	0 12 38.96	+ 2 51 33.5	−3.8	− 24
787 *Moskva*	12.3	Sept. 29	15 52.0	0 24 26.35	+ 1 36 20.6	+0.9	− 1
536 *Merapi*	11.3	Sept. 29	17 05.0	2 05 35.94	− 6 46 24.9	−0.6	+ 6
787 *Moskva*	12.3	Oct. 3	16 27.0	0 21 30.37	+ 0 44 18.4	+0.9	− 1
240 *Vanadis*	11.5	Oct. 27	13 36.6	* 0 10 12.44	− 2 43 19.4	+5.5	+ 33
536 *Merapi*	11.3	Oct. 27	15 08.6	1 43 17.67	− 7 01 05.9	−0.6	+ 8
787 *Moskva*	12.3	Nov. 14	13 11.0	0 06 26.03	− 5 14 11.3	+0.8	+ 1
787 *Moskva*	12.3	Nov. 15	13 37.0	0 06 34.98	− 5 17 46.3	+0.8	+ 1
92 *Undina*	10.7	Nov. 15	14 52.6	1 27 01.50	− 5 12 25.0	−0.2	− 2
92 *Undina*	10.7	Nov. 17	14 04.0	1 26 07.11	− 5 10 09.6	−0.2	− 2
92 *Undina*	10.7	Nov. 17	14 29.5	1 26 07.05	− 5 10 08.4	−0.2	− 2

Name	Mag.	Date	G.M.T.	Astrographic 1925.0 α	Astrographic 1925.0 δ	O — C α	O — C δ
		1919	h m	h m s	° ′ ″	m	′
787 *Moskva*	12.3	Nov. 18	13 16.0	0 07 10.38	− 5 25 25.7	+0.8	+ 1
		1920					
67 *Asia*	12.1	Jan. 14	15 45.5	7 01 27.67	+13 27 26.5	−2.9	+ 3
67 *Asia*	12.1	Jan. 18	14 43.0	7 00 33.76	+13 36 17.1	−2.8	+ 3
925 *Alphonsina*	10.0	Jan. 28	14 06.5	* 7 18 23.02	+20 50 49.4	−0.2	− 2
287 *Nephthys*	10.9	Feb. 10	14 06.0	7 45 40.10	+16 26 56.3	+3.5	+ 3
287 *Nephthys*	10.9	Feb. 13	13 52.3	7 43 32.34	+16 48 43.1	+3.4	+ 3
158 *Koronis*	12.2	Feb. 16	15 17.0	8 50 35.32	+16 46 27.0	−3.0	+ 12
526 *Jena*	12.3	Feb. 16	15 17.0	8 55 53.40	+17 17 19.8	+8.9	− 30
569 *Misa*	11.6	Feb. 16	15 17.0	8 59 37.70	+16 27 32.0	+0.1	− 1
158 *Koronis*	12.2	Feb. 17	14 21.1	8 49 49.71	+16 49 21.2	−3.0	+ 12
526 *Jena*	12.3	Feb. 17	14 21.1	8 55 10.94	+17 21 06.4	+8.9	− 30
569 *Misa*	11.6	Feb. 17	14 21.1	8 58 49.31	+16 30 22.8	+0.1	− 1
925 *Alphonsina*	10.0	Feb. 25	14 33.9	7 25 35.88	+17 50 41.2	−0.2	− 1
925 *Alphonsina*	10.0	Mar. 17	15 10.0	7 24 43.55	+15 48 13.7	+0.1	− 1
127 *Johanna*	10.3	Mar. 24	15 41.7	11 58 07.67	+ 7 56 03.9	−3.7	+ 26
261 *Prymno*	10.9	Mar. 27	16 58.3	11 44 36.70	+ 8 57 25.7	0	− 2
127 *Johanna*	10.3	Mar. 27	16 58.3	11 55 23.75	+ 8 03 00.5	−3.7	+ 26
261 *Prymno*	10.9	Apr. 14	14 34.0	11 32 35.12	+ 9 48 06.3	+0.2	− 2
232 *Russia*	12.3	Apr. 14	16 00.0	12 54 48.24	+ 2 53 51.0	+7.8	− 33
128 *Nemesis*	11.3	Apr. 14	16 00.0	12 55 07.01	+ 2 46 37.6	−0.1	0
128 *Nemesis*	11.3	Apr. 21	14 45.0	12 49 46.12	+ 3 08 02.0	0	0
232 *Russia*	12.3	Apr. 21	14 45.0	12 50 14.91	+ 3 34 14.1	+7.6	− 33
70 *Panopaea*	10.9	Apr. 21	16 05.5	13 16 27.21	+ 0 37 56.9	+0.1	− 6
70 *Panopaea*	10.9	Apr. 24	15 57.0	13 13 34.92	+ 0 39 59.4	+0.1	− 6
628 *Christine*	12.4	Apr. 21	16 58.0	13 44 20.08	+ 8 51 43.6	−1.2	+ 4
628 *Christine*	12.4	May 14	15 10.0	13 29 44.76	+ 9 02 29.9	−1.2	+ 4
200 *Dynamene*	10.8	Sept. 13	15 13.0	22 59 08.07	− 1 46 15.1	−0.2	+ 1
189 *Phthia*	11.4	Sept. 13	15 13.0	23 03 21.57	− 0 30 08.4	+5.9	+ 27
345 *Tercidina*	11.2	Sept. 13	16 24.0	23 09 35.57	+ 6 58 04.6	−3.6	− 22
200 *Dynamene*	10.8	Sept. 14	14 29.0	22 58 14.31	− 1 48 59.8	−0.2	0
189 *Phythia*	11.4	Sept. 14	14 29.0	23 02 32.18	− 0 37 56.3	+5.8	+ 27
345 *Tercidina*	11.2	Sept. 14	16 25.2	23 08 44.63	+ 6 48 31.3	−3.6	− 22
385 *Ilmatar*	11.0	Sept. 15	16 29.0	23 43 33.14	+ 2 04 11.9	−0.8	− 2
136 *Austria*	10.8	Sept. 15	16 29.0	23 55 10.54	+ 2 48 22.6	+3.4	+ 6
136 *Austria*	10.8	Sept. 17	16 22.0	23 54 05.66	+ 2 25 07.3	+3.5	+ 7
72 *Feronia*	10.7	Oct. 5	15 30.3	0 19 24.63	+ 5 38 43.3	+0.6	− 1
149 *Medusa*	11.7	Oct. 5	16 45.7	0 32 59.98	+ 2 31 44.4	+2.6	+ 15
195 *Eurykleia*	12.7	Oct. 5	16 45.7	0 36 17.03	+ 4 34 43.5	−0.4	+ 3
72 *Feronia*	10.7	Oct. 11	15 29.0	0 11 39.52	+ 4 43 06.6	+0.7	− 1
91 *Aegina*	10.6	Oct. 13	15 34.3	0 17 37.28	+ 1 54 07.8	+0.4	0
91 *Aegina*	10.6	Oct. 14	16 13.2	0 16 47.85	+ 1 49 50.5	+0.4	0
195 *Eurykleia*	12.7	Oct. 15	15 58.6	0 27 59.59	+ 4 01 19.6	−0.4	+ 3
302 *Clarissa*	13.2	Nov. 12	15 18.3	1 29 41.71	+12 31 51.4	−1.7	− 10
302 *Clarissa*	13.2	Nov. 13	14 50.0	1 29 01.96	+12 29 08.6	−1.8	− 10
		1921					
536 *Merapi*	11.8	Jan. 3	14 00.7	* 6 05 36.55	+38 50 25.8	+8.2	+ 50
160 *Una*	11.7	Feb. 11	16 35.0	* 9 59 13.91	+16 10 01.1	−0.7	+ 2
213 *Lilaea*	12.2	Feb. 11	16 35.0	10 10 15.79	+15 56 37.0	+1.2	0
160 *Una*	11.7	Feb. 15	17 03.5	* 9 58 17.11	+16 43 52.6	−0.6	+ 3

Name	Mag.	Date	G.M.T.	Astrographic 1925.0 α	Astrographic 1925.0 δ	O–C α	O–C δ
		1921	h m	h m s	° ′ ″	m	′
213 *Lilaea*	12.2	Feb. 15	17 03.5	10 09 54.69	+16 03 15.8	+1.2	0
176 *Iduna*	12.6	June 12	15 43.0	16 39 27.14	+ 3 05 59.2	−0.3	+ 1
176 *Iduna*	12.6	June 14	15 58.0	16 38 01.12	+ 3 11 20.4	−0.3	+ 1
176 *Iduna*	12.6	June 27	15 08.0	16 29 35.07	+ 3 28 50.0	−0.3	+ 1
41 *Daphne*	9.3	July 2	15 55.0	18 31 57.19	+ 4 35 30.1	−3.9	− 12
41 *Daphne*	9.3	July 25	14 29.5	18 19 53.91	+ 1 52 20.9	−3.9	− 11
754 (1906 *VT*)	13.1	July 27	16 22.0	20 13 55.28	+ 9 58 05.0	+0.1	+ 6
754 (1906 *VT*)	13.1	Aug. 4	16 10.0	20 08 07.87	+ 9 04 25.4	+0.1	+ 6
123 *Brunhild*	11.5	Sept. 23	15 29.0	23 49 34.40	+ 8 00 06.0	−0.8	− 4
123 *Brunhild*	11.5	Sept. 28	15 45.5	23 45 08.88	+ 7 39 28.1	−0.8	− 4
180 *Garumna*	13.5	Sept. 30	15 57.0	0 40 54.60	+ 5 37 35.0	+1.4	+ 9
180 *Garumna*	13.5	Oct. 1	15 59.0	0 40 03.79	+ 5 32 27.7	+1.4	+ 9
1921 *W* 18	12.6	Oct. 5	15 41.0	0 53 56.70	+ 5 41 59.9	New?	
540 *Rosamunde*	12.6	Oct. 5	15 41.0	0 58 37.65	+ 7 33 49.7	+1.6	+ 5
915 (1918*b*)	13.0	Oct. 5	15 41.0	1 03 02.56	+ 7 56 20.2	+0.5	+ 7
540 *Rosamunde*	12.6	Oct. 5	16 59.5	0 58 34.63	+ 7 33 25.4	+1.6	+ 5
29 *Amphitrite*	8.8	Oct. 5	16 59.5	1 04 11.30	+10 17 55.5	−4.9	− 37
915 (1918*b*)	13.0	Oct. 5	16 59.5	1 02 59.18	+ 7 56 15.4	+0.5	+ 7
1921 *W* 18	12.6	Oct. 6	16 53.5	0 53 06.70	+ 5 37 56.8	New?	
540 *Rosamunde*	12.6	Oct. 6	16 53.5	0 57 38.51	+ 7 21 53.8	+1.6	+ 5
915 (1918*b*)	13.0	Oct. 6	16 53.5	1 01 56.10	+ 7 54 44.1	+0.5	+ 7
161 *Athor*	10.5	Oct. 6	16 53.5	1 06 47.12	+ 6 12 33.1	−1.4	− 9
29 *Amphitrite*	8.8	Oct. 8	15 52.0	* 0 58 50.34	+10 09 44.9	−5.0	− 38
258 *Tyche*	9.8	Oct. 8	15 52.0	* 1 07 16.56	+12 21 20.1	−0.2	+ 3
161 *Athor*	10.5	Oct. 8	16 50.0	1 04 35.12	+ 6 10 32.8	−1.4	− 9
540 *Rosamunde*	12.6	Oct. 8	16 50.0	0 55 45.36	+ 7 07 47.1	+1.6	+ 5
915 (1918*b*)	13.0	Oct. 8	16 50.0	0 59 18.28	+ 7 51 27.0	+0.5	+ 7
258 *Tyche*	9.8	Oct. 21	14 37.0	0 59 08.20	+ 9 10 54.3	−0.2	+ 3
211 *Isolda*	10.9	Oct. 22	14 34.0	0 59 28.32	+12 12 27.3	−1.3	− 10
368 *Haidea*	12.9	Oct. 22	14 34.0	1 07 36.55	+12 49 25.1	−0.1	− 3
374 *Burgundia*	12.0	Oct. 22	14 34.0	1 14 12.19	+11 46 09.2	−0.6	− 6
248 *Lameia*	13.3	Oct. 22	15 47.0	1 29 06.97	+13 49 21.9	−6.5	− 33
211 *Isolda*	10.9	Oct. 24	15 13.0	0 58 00.21	+12 09 52.4	−1.4	− 10
368 *Haidea*	12.9	Oct. 24	15 13.0	1 06 13.69	+12 33 54.6	−0.1	− 3
374 *Burgundia*	12.0	Oct. 24	15 13.0	1 12 41.36	+11 30 48.3	−0.6	− 6
248 *Lameia*	13.3	Oct. 24	16 27.0	1 27 18.12	+13 35 39.0	−6.5	− 33
211 *Isolda*	10.9	Oct. 26	14 15.0	0 56 37.03	+11 49 36.0	−1.4	− 10
368 *Haidea*	12.9	Oct. 26	14 15.0	1 04 55.82	+12 18 52.9	0.0	− 1
374 *Burgundia*	12.0	Oct. 26	14 15.0	1 11 14.41	+11 15 52.6	−0.6	− 6
468 *Lina*	12.1	Oct. 28	15 54.0	1 26 36.90	+ 9 41 15.2	−0.6	− 1
211 *Isolda*	10.9	Nov. 4	14 31.0	0 51 03.99	+11 00 12.1	−1.4	− 11
368 *Haidea*	12.9	Nov. 4	14 31.0	0 59 48.36	+11 13 35.6	0.0	− 1
374 *Burgundia*	12.0	Nov. 4	14 31.0	* 1 05 18.58	+10 10 39.3	−0.6	− 6
468 *Lina*	12.1	Nov. 7	14 21.0	* 1 20 10.64	+ 8 35 30.5	−0.6	− 1
980 *Anacostia*	10.5	Nov. 21	11 26.0	22 13 36.04	+ 9 36 28.6	0.0	0
433 *Eros*	10.8	Nov. 21	11 26.0	22 22 07.04	+ 9 13 11.5	0.0	+2.3
433 *Eros*	10.8	Nov. 22	11 21.0	22 23 29.46	+ 9 11 12.1	0.0	+2.1
62 *Erato*	11.2	Nov. 22	15 18.0	3 01 17.89	+13 34 53.4	−3.4	− 15
980 *Anacostia*	10.5	Nov. 25	11 16.0	22 18 26.56	+ 9 40 07.9	0.0	0
433 *Eros*	10.8	Nov. 25	11 16.0	22 27 18.35	+ 9 18 55.5	0.0	+2.7

Name	Mag	Date	G.M.T.	Astrographic 1925.0 α	δ	O — C α	δ
		1921	h m	h m s	° ′ ″	m	′
62 *Erato*	11.2	Nov. 25	11 10.0	2 59 06.06	+13 27 18.1	−3.3	−14
980 *Anacostia*	10.5	Nov. 29	11 12.0	22 23 31.09	+ 9 46 01.3	0.0	0
416 *Vaticana*	12.5	Nov. 29	14 18.0	3 05 28.94	+15 52 46.7	−2.2	−11
980 *Anacostia*	10.5	Dec. 1	11 18.0	22 26 13.89	+ 9 49 48.8	0.0	0
433 *Eros*	10.8	Dec. 3	11 12.0	22 40 19.08	+ 9 39 59.4	0.0	+1.7
980 *Anacostia*	10.5	Dec. 3	11 12.0	*22 28 57.52	+ 9 54 16.3	0.0	0
416 *Vaticana*	12.5	Dec. 3	14 23.0	3 02 13.72	+15 51 09.4	−2.2	−11
980 *Anacostia*	10.5	Dec. 9	10 58.0	22 37 26.60	+10 10 30.5	0.0	0
980 *Anacostia*	10.5	Dec. 22	10 52.0	22 57 23.24	+11 01 31.7	0.0	0
980 *Anacostia*	10.5	Dec. 27	11 08.0	23 05 33.25	+11 26 31.6	0.0	0
		1922					
980 *Anacostia*	10.5	Jan. 2	11 11.0	23 15 38.05	+11 59 43.8	0.0	0
980 *Anacostia*	10.5	Jan. 7	10 57.0	23 24 13.82	+12 29 58.8	0.0	0
980 *Anacostia*	10.5	Jan. 11	11 16.0	23 36 37.08	+13 16 06.1	0.0	0
980 *Anacostia*	10.5	Jan. 24	11 34.0	23 54 48.95	+14 27 55.8	0.0	+ 1
600 *Musa*	13.3	Jan. 24	15 06.0	7 17 55.50	+15 28 35.2	−0.9	+ 2
980 *Anacostia*	10.5	Jan. 25	11 44.4	*23 56 40.79	+14 35 29.5	0.0	+ 1
600 *Musa*	13.3	Jan. 25	15 10.0	7 17 03.67	+15 34 14.2	−0.9	+ 2
189 *Phthia*	11.7	Jan. 30	14 42.0	7 57 40.37	+12 13 18.2	+0.8	0
713 (1913 *QV*)	12.9	Jan. 30	14 42.0	* 8 03 45.64	+13 03 32.1	−3.0	+ 10
168 *Sibylla*	11.6	Jan. 30	16 10.0	8 28 30.63	+12 27 07.9	−3.3	+ 12
239 *Adrastea*	14.0	Jan. 30	16 10.0	8 37 51.66	+10 58 37.1	+1.7	− 5
189 *Phthia*	11.7	Jan. 31	14 27.0	7 56 44.76	+12 17 19.2	+0.8	0
713 (1913 *QV*)	12.9	Jan. 31	14 27.0	8 02 53.83	+13 06 26.9	−3.0	+ 10
168 *Sibylla*	11.6	Jan. 31	15 54.0	8 27 46.55	+12 30 44.4	−3.3	+ 12
239 *Adrastea*	11.0	Jan. 31	15 54.0	8 37 00.96	+11 03 18.6	+1.7	− 5
206 *Hersilia*	11.9	Feb. 24	15 43.8	9 31 24.41	+14 45 08.3	−0.4	+ 4
206 *Hersilia*	11.9	Feb. 27	14 26.0	9 29 08.52	+15 00 22.4	−0.4	+ 4
860 (1917 *BD*)	13.4	Feb. 28	14 52.0	* 9 37 45.30	+ 7 18 19.1	−1.6	+ 14
536 *Merapi*	12.2	Feb. 28	16 25.0	*10 59 42.62	+34 41 24.8	−1.1	+ 5
860 (1917 *BD*)	13.4	Mar. 5	15 41.0	9 33 36.13	+ 7 26 37.2	−1.6	+ 15
536 *Merapi*	12.2	Mar. 17	14 17.0	*10 46 23.55	+35 10 37.4	−1.0	+ 5
335 *Roberta*	12.0	Mar. 17	15 41.0	10 57 38.28	+ 9 34 47.6	−3.6	+ 19
58 *Concordia*	11.4	Mar. 17	15 41.0	*11 02 53.17	+ 7 15 21.4	+0.3	− 2
536 *Merapi*	12.2	Mar. 22	14 15.0	*10 42 52.88	+35 08 19.1	−1.1	+ 5
335 *Roberta*	12.0	Mar. 22	15 40.0	10 53 29.51	+10 07 51.0	−3.6	+ 19
58 *Concordia*	11.4	Mar. 22	15 40.0	10 59 14.30	+ 7 48 14.0	+0.3	− 2
312 *Pierretta*	12.4	Mar. 23	16 27.0	11 24 31.01	+ 7 25 29.8	−0.5	+ 4
26 *Proserpina*	10.2	Mar. 25	15 55.0	12 02 21.58	+ 4 48 31.5	−1.2	+ 6
357 *Ninina*	12.6	May 15	15 17.0	14 47 45.36	+ 5 45 38.8	+0.2	− 7
357 *Ninina*	12.6	May 19	15 14.0	14 45 02.38	+ 5 51 13.9	+0.2	− 7
483 *Seppina*	12.6	May 24	16 14.0	15 29 59.19	+ 4 05 38.3	+1.1	− 3
483 *Seppina*	12.6	May 29	15 25.5	15 26 48.24	+ 4 19 15.0	+1.0	− 3
729 (1912 *OD*)	12.4	June 21	16 14.0	16 35 59.31	− 0 01 59.4	+5.3	− 28
729 (1912 *OD*)	12.4	June 23	15 09.0	16 34 31.51	− 0 16 02.7	+5.3	− 28
276 *Adelheid*	12.2	June 23	16 50.0	19 05 54.45	+ 6 28 13.8	+0.3	+ 5
		1923					
10 *Hygiea*	9.7	Sept. 10	15 07.0	22 29 23.44	− 4 38 20.2	+0.1	+ 1
94 *Aurora*	11.0	Sept. 16	16 17.0	23 21 15.00	− 7 22 08.9	+1.5	+ 15
10 *Hygiea*	9.7	Sept. 17	15 56.0	22 24 38.06	− 5 05 56.6	0.0	− 1
94 *Aurora*	11.0	Sept. 17	16 51.0	23 20 25.48	− 7 24 41.3	+1.5	+ 15

The foregoing list of asteroids was observed by G. H. Peters with the 10-inch photographic equatorial of the U. S. Naval Observatory.

The Clark driving clock, originally furnished with the equatorial mounting of this telescope, was discarded April 5, 1921, and a new electric driving clock was installed which has been described and illustrated in *Popular Astronomy*, Vol. XXX, No. 2. This clock which has proven eminently satisfactory from the time of its installation has been in use since June 3, 1921.

Asteroid (787) *Moskva* was found upon a plate exposed for (277) *Elvira*. No ephemeris was available for (787) at the Naval Observatory at that time, and suspecting that it might be new, from its rapid decrease in declination, an extended series of observations was made from which to derive elements of its orbit. Asteroid (980) *Anacostia* was also found by the observer on a plate exposed for (433) *Eros*, and since it is new the number (980) has been recently assigned to it by the Rechen-Institut.

The author has made the photographic observations, examined the plates, selected and reduced the comparison stars and measured all of the plates containing these asteroids.

In the list of asteroids those marked with an asterisk (*) are the positions resulting from plate measures reduced by the method of least squares taking account of the center of gravity of the group of stars about the asteroid. This is a form somewhat similar to that used by Wilson and Gingrich.* Those not so designated have been reduced by rectangular coordinates with adjustment for orientation of the plates measured. In most cases four or more comparison stars have been employed.

Most of the observations were reduced in the Computing Division under the direction of Miss E. A. Lamson. The observed positions have been compared with ephemerides and with available published observations. In this work the motions were checked by comparison with those given in the ephemerides and in a few cases it was found necessary to compute extensions to these ephemerides. With the exception of one asteroid, provisionally designated as (1921 W 18), all have been identified.

The column (O–C) which appears in the list represents the comparison of the observation with the ephemeris. The ephemeris used in most cases is that to be found in the *Oppositions-Ephemeriden* published by the Rechen-Institut. In a number of cases where later or better ephemerides could be found in the *Circulaire de Marseille* or the *Beobachtungs-Zirkulare* the comparison has been made with them.

The last four observations (in 1923) are of asteroids which were observed at the request of Prof. A. O. Leuschner. They are published in advance of other observations which have been made, but not yet reduced.

*See Publications of the Goodsell Observatory of Carleton College, No. 5.

EPHEMERIS OF ENCKE'S COMET,

By FRANK E. SEAGRAVE.

1924 G. Midnight		α h m s	δ ° ′ ″	Log r	Log Δ
July	1	2 18 48	+21 13 24	0.31152	0.37044
	5	2 26 6	+22 2 47	0.30242	0.35435
	9	2 33 40	+22 53 19	0.29292	0.33749
	13	2 41 33	+23 45 7	0.28302	0.31985
	17	2 49 48	+24 38 9	0.27272	0.30141
	21	2 58 29	+25 32 43	0.26192	0.28211
	25	3 7 38	+26 28 39	0.25064	0.26191
	29	3 17 24	+27 26 23	0.23876	0.24076
Aug.	2	3 27 11	+28 22 56	0.22636	0.21795
	6	3 38 58	+29 26 20	0.21330	0.19561
	10	3 51 6	+30 28 35	0.19954	0.17155
	14	4 4 23	+31 32 4	0.18498	0.14645
	18	4 19 1	+32 36 12	0.16956	0.12035
	22	4 35 20	+33 40 6	0.15322	0.09322
	26	4 53 31	+34 42 11	0.13580	0.06544
	30	5 14 5	+35 40 2	0.11720	0.03693
Sept.	3	5 37 24	+36 29 53	0.09728	0.00812
	7	6 3 51	+37 6 44	0.07586	9.97952
	11	6 33 11	+37 21 34	0.05274	9.95187
	15	7 7 7	+37 5 56	0.02764	9.92620
	19	7 43 39	+36 8 9	0.00020	9.90388
	23	8 22 19	+34 18 47	9.97014	9.88652
	27	9 1 11	+31 32 19	9.93696	9.87588

Comet should be found in *Aries*, in the morning sky during the first part of July.

Perihelion passage, October 31.894, 1924 G. M. T.

It will be nearest the *Earth* on September 27, 1924, Δ = 0.751.

Boston, Mass.,
December 28, 1923.

OBSERVATIONS OF COMET D'ARREST-REID (1923*b*),

By G. VAN BIESBROECK.

a) Visual Observations with the 40-inch Refractor

1923	G.M.T.	Δα	Δδ	N	α App.	δ App.	Parall.		
Dec. 6	14h 30m 22s	+0m 25s.64	+2′ 26″.4	8 8	22h 54m 55s.21	−24° 3′ 53″.6	9.845	0.871	1
Dec. 10	12 14 1	+3 17 .68	+4 48 .4	25 5	23 5 58 .53	−23 6 31 .5	8.767	0.902	2

Comparison Stars (1923.0)

No.	α (1923.0)	δ (1923.0)	Red. α	Red. δ	Authority
1	22h 54m 27s.36	−24° 6′ 34″.2	+2s.21	+11″.2	*A. G. Cord A.* 15461
2	23 2 38 .65	−23 11 31 .0	+2 .20	+14 .1	*A. G. Cord A.* 15539

b) Photographic Observations with the 24-inch Reflector

1924	G.M.T.	1924.0	1924.0	Parall.		Comparison stars
	h m s	h m s	° ′ ″			
Jan. 1	12 28 11	0 2 37.48	−17 19 19.2	9.151	0.871	Hyder. 0h 4m, −17° Ns. 151, 152, 165.
1	12 46 3	2 38.89	17 19 9.7	9.243	0.871	Hyder. 0h 4m, −17° Ns. 151, 152, 165.
3	13 12 17	7 25.47	16 46 34.8	9.355	0.863	Hyder. 0h 4m, −17° Ns. 95, 105, 110.
3	13 31 11	7 26.82	16 46 18.6	9.419	0.857	Hyder. 0h 4m, −17° Ns. 95, 105, 110.
5	12 7 30	12 0.03	16 15 3.4	9.056	0.872	Hyder. 0h 12m, −17° Ns. 339, 331, 340.
5	12 27 9	12 1.66	16 14 49.1	9.179	0.870	Hyder. 0h 12m, −17° Ns. 339, 331, 340.
23	12 23 11	51 59.03	11 29 5.4	9.294	0.843	*A. G. Harv.* 178
23	12 57 5	52 2.46	11 28 44.4	9.401	0.832	*A. G. Harv.* 178
26	12 52 20	0 58 21.22	−10 42 36.0	9.402	0.833	*A. G. Harv.* 204, 241.

REMARKS

All observations are corrected for refraction. No correction for aberration is applied to the photographic positions.

Dec. 6. Through clouds.

Dec. 10. Total magnitude 13. In the 40-inch refractor the comet appears as a round nebulosity about 45″ in diameter, with only a slight condensation toward a 14m nucleus.

A 60 min. exposure with the 24-inch reflector by O. Struve shows the nebulosity extending as far as 90″ from the nucleus; its densest part is in position angle 300°, while in the opposite direction it is very faint. There is a general condensation toward the nucleus.

Jan. 1. On the plates the object appears as a very diffuse nebulosity about 30″ in diameter, which is very difficult to measure. The second plate deserves double weight. Total magnitude 15.

Jan. 3. Images very faint.

Jan. 5. Round nebulosity about 25″ in diameter, with only very slight central condensation. Total magnitude 15.5.

Jan. 7. Seen at the limit of visibility of the 10-inch as a diffuse nebulosity without nucleus. No comparison stars near.

Jan. 23. The first plate was exposed by O. STRUVE. Allowance was made for the motion of the object in guiding. The comet appears as a round nebulosity with hardly any central condensation, about 20″ in diameter. Magnitude 16.

Jan. 26. With guiding for the motion. A little central condensation. Magnitude 16.

Yerkes Observatory, Williams Bay, Wis.,
February 29, 1924.

REDUCTION OF OCCULTATIONS OF STARS BY THE *MOON*.

BY R. T. A. INNES.

It is to be regretted that very few of the occultations of the stars by the *Moon* actually recorded are made any use of. One reason for this is that the reduction of an occultation, unless made at the place of observation, is somewhat uncertain. The calculator may be in doubt as to the position of the telescope and its altitude, the sidereal time at the telescope, etc. For these, and perhaps other reasons, unreduced occultations are often lost to science. Yet the observations have considerable value. Their only uncertainty to-day arises from the irregularities of the *Moon's* edge and in the mean of a series the errors so arising will be eliminated.

Since the beginning of this year, BROWN'S Tables have been used for the Ephemerides given in the *Nautical Almanac* and the *American Ephemeris*. It is therefore desirable to have as complete a record of observation as possible so as to make the comparison from day to day as exact as possible. Occultations can materially assist and add to the results which will be derived from meridian observations.

In the hope that observers may be tempted to reduce their observations, I give the formulas made use of here. They make no claim to novelty, but I claim that they give the excess of the star's distance over the *Moon's* radius with precision and cannot be excelled for brevity or accuracy. Having this excess $(\sigma' - \sigma)$ we go directly to the quantity Δv wanted by the investigator, namely the error in orbital longitude. It is assumed that the error perpendicular to the orbit is insensible.

Occultations: Working formulæ

T = Greenwich Time of Observation
α and δ = *Moon's* R.A. and Dec. from the Ephemeris for the time T
α' and δ' = Star's apparent place
θ = Local Sidereal Time at the Telescope
π = *Moon's* Parallax as given in the Ephemeris for the time T.
$\pi'' = \pi - 0''.16.$

$$X = \rho' \cos \varphi' \qquad Y = \rho' \sin \varphi'$$

ρ' = Distance from centre of *Earth* including the effect of altitude.
φ' = Geocentric Latitude.
(These are generally given in the *American Ephemeris*.)

$$X'' = X \times \pi'' \qquad Y'' = Y \times \pi''$$

$$\sigma = \pi'' \, [9.43536] = \text{Semi-diameter of } Moon$$

Use 5-figure logarithms

$$x = 15\,(\alpha' - \alpha)^s \cos \delta$$
$$y = (\delta' - \delta) - [4.385]\, x^2 \sin \delta' \cos \delta$$

$$\xi = X'' \sin (\theta - \alpha')$$
$$\eta = Y'' \cos \delta' - X'' \sin \delta' \cos (\theta - \alpha')$$

Diminish the numerical values of $(\alpha' - \alpha)$ and of $(\delta' - \delta)$ as follows:

From 0″	to 2286″	by 0″.0
From 2287	to 3365	by 0 .1
From 3366	to 3996	by 0 .2
From 3997	to 4470	by 0 .3

Then

$$\tan \chi = \frac{x + \xi}{y + \eta} \qquad \chi = \text{Angle of occultation}$$

and

$$\sigma' = \frac{x + \xi}{\sin \chi} = \frac{y + \eta}{\cos \chi} = \left\{ \text{Observed distance of star and } Moon\text{'s centre at time of occultation.} \right.$$

Put

$\Delta\alpha$ = Variation of α in 1 min. at time T
$\Delta\delta$ = Variation of δ in 1 min. at time T

Then

$$\tan \rho = \frac{15\, \Delta\alpha \cos \delta}{\Delta\delta} \qquad \rho = \text{Direction of } Moon\text{'s motion.}$$

and the error in orbital longitude in the sense O—C is

$$\Delta v = (\sigma' - \sigma) / \cos (\chi - \rho)$$

Lastly, if the zenith distance is very great the following corrections should be applied to the fifth decimals of the logarithms of X'' and Y''.

Zenith Distance	Correction
72° to 84°	+1
85° to 86°	+2
87°	+3
88°	+4
89°	+5
89° to 89° 24′	+8

This is the correction for refraction with which HANSEN puzzled GAUSS.

It might be remarked that if more than one occultation has been observed, the correction Δv should be derived differently. The cosine of $\chi-\rho$ then becomes the weight of the observation. Thus on 1923, August 16, five occultations were observed giving

	$\sigma'-\sigma$	$\cos(\chi-\rho)$
	$+7''.1$	0.702
	6 .7	0.840
	5 .0	0.437
	7 .5	0.938
	6 .9	0.822
Sums	+33 .2	3.739 ∴ $\Delta v = +8''.9$

Similarly 6 occultations on the 17th, and 6 on the evenings of 18, 19 and 20th gave respectively $+8''.8$ and $+8''.9$.

If many occultations on one night well distributed around the *Moon's* edge are available, it may be worth while also solving for $\Delta\beta$, the perpendicular distance of the *Moon* from its computed orbit; if so we shall have equations of the form

$$\sigma'-\sigma = \Delta v \cos(\chi-\rho) + \Delta\beta \sin(\chi-\rho)$$

which should be solved by least squares.

The accuracy aimed at is $\pm 0''.1$ which is a little more than is possible with tabular lunar places to 0.01 sec. and $0''.1$ in α and δ.

The quantity $\pi'' = \pi - 0''.16$ is the sine of the *Moon's* parallax multiplied by the radian in seconds. Much more rigorously $\pi'' = \pi\left(1-\frac{1}{2000}\right)$ which is just as easily computed.

ρ is used with two different meanings, but there is no clashing.

If in the formula for x we replace log 15 = 1.17609 by 1.17608, the correction to $(\alpha'-\alpha)$ may be omitted with almost equal accuracy.

The use of ZECH'S Addition and Substraction Logarithms slightly shortens the work and increases its accuracy.

Union Observatory, Johannesburg, South Africa, February 4, 1924.

THE PROPER-MOTION OF *B. D.* −8° 5980.

By L. J. COMRIE.

The P. M. of this star is of some small interest, firstly because it exceeds 50″ a century, and secondly because the star lies near the ecliptic and was suggested as a comparison star for *Uranus* during the opposition of 1922. An approximate value of the P. M. was given in *Journal of the British Astronomical Association*, XXXII. 182 by the writer, who was not then aware of a similar value published by BATTERMANN in *Berliner Beobachtungs-Ergebnisse* No. 10.

PROFESSOR TUCKER kindly observed the star at the end of 1922 with the transit circle of the *Lick Observatory*, while SR. HERRERO, of San Fernando, communicated two unpublished astrographic positions. The solution below is based on all the material now available. Systematic corrections have been applied to reduce the observations to the Boss system.

A least square solution gives for 1900·0

$$\alpha \quad 22^h\ 50^m\ 33^s\cdot40 \qquad \mu_\alpha\ +0^s\cdot0372$$
$$\delta \quad -8°\ 21'\ 46''\cdot4 \qquad \mu_\delta\ -0''\cdot060$$

The total annual P.M. is 0″·555 in P.A. 96°·2.

Sproul Observatory, Swarthmore, Pa., 1924 March 24.

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THE PARALLAX AND THE ORBITAL MOTION OF ξ URSÆ MAJORIS.*

By CARL L. STEARNS.

This star is a well-known visual binary with a period of 59.8 years. The visual magnitudes of the two components are 4.4 and 4.9, and their masses are approximately equal,† each being about half that of the Sun. The spectra are given in the *Henry Draper Catalogue* as G0. This is one of the few visual binaries which have made complete revolutions since their discovery, and it has the distinction of being the first double star to have its orbit computed, this having been done by SAVARY in 1828. Since that time observers and computers have devoted much attention to the system, with the result that it has been found to be triple instead of double. The first evidence of the presence of a third body in the system was obtained in 1900, when WRIGHT‡ announced that the brighter component was a spectroscopic binary with a period of 1.8 years; and in 1905 NÖRLUND§ in computing the orbit of the visual pair, found that the motion was not

TABLE I

Plate No. and observer	Date	Hour angle	Parallax factor	Time	Weight	Brighter Component: Solution	Brighter Component: Corrected Solution	Brighter Component: Resid.	Fainter Component: Solution	Fainter Component: Corrected Solution	Fainter Component: Resid.	Remarks
		min.		days		mm.	mm.	″	mm.	mm.	″	
907J	1914 Dec. 21	− 7	+0.88	− 507	0.5	+0.0805	+0.0805	−0.061	+0.0831	+0.0831	+0.025	
1005H	1915 Jan. 4	−34	+ .82	− 493	1.0	+ 833	+ 833	+ 9	+ 765	+ 765	− 45	
1072J	9	−20	+ .78	− 488	1.0	+ 845	+ 846	+ 39	+ 795	+ 794	+ 9	
1972J	May 5	+19	− .78	− 372	1.0	+ 546	+ 551	− 36	+ 532	+ 527	+ 3	
2005H	10	+24	− .83	− 367	1.0	+ 578	+ 583	+ 22	+ 544	+ 539	+ 34	Four exposures
5252T	1916 Apr. 30	+ 9	− .73	− 11	1.0	+ 358	+ 374	− 4	+ 233	+ 217	− 57	Four exposures
5282D	May 7	+12	− .81	− 4	1.0	+ 344	+ 360	− 7	+ 263	+ 247	+ 7	
5301J	8	0	− .82	− 3	0.7	+ 356	+ 372	+ 12	+ 300	+ 284	+ 66	
8412T	1917 Jan. 1	+10	+ .83	+ 235	0.8	+ 212	+ 233	− 29	+ 294	+ 273	+ 41	
8580h	24	0	+ .62	+ 258	0.5	+ 209	+ 230	+ 25	+ 162	+ 141	− 91	
9302h	May 9	+21	− .82	+ 363	0.8	0	+ 22	+ 6	− 18	− 40	− 3	Two exposures
9310T	10	+17	− .83	+ 364	0.8	− 16	+ 6	− 16	− 41	− 63	− 35	
9363T	15	+13	− .86	+ 369	0.8	+ 10	+ 32	+ 31	− 19	− 41	+ 7	
11590C	Dec. 17	0	+ .89	+ 585	0.7	+ 52	+ 75	+ 35	+ 7	− 16	− 3	
11891J	1918 Jan. 20	0	+ .66	+ 619	0.7	− 36	− 13	− 34	− 112	− 35	+ 45	
20114J	1920 May 1	+ 2	− .75	+1451	1.0	− 769	− 765	+ 12	− 849	− 853	+ 6	
20147J	3	0	− .77	+1453	1.0	− 772	− 768	+ 13	− 851	− 855	+ 6	
20216J	7	0	− .81	+1457	1.0	− 807	− 803	− 25	− 873	− 877	− 15	

*$\alpha = 11^h\ 13^m$, $= +32°\ 6'$ (1900).

†Boss, *Preliminary General Catalogue*, p. 269.

‡*Astrophysical Journal*, **12**, 251, 1900, and *Lick Observatory Bulletin* 133.

§*Astronomische Nachrichten* 4064.

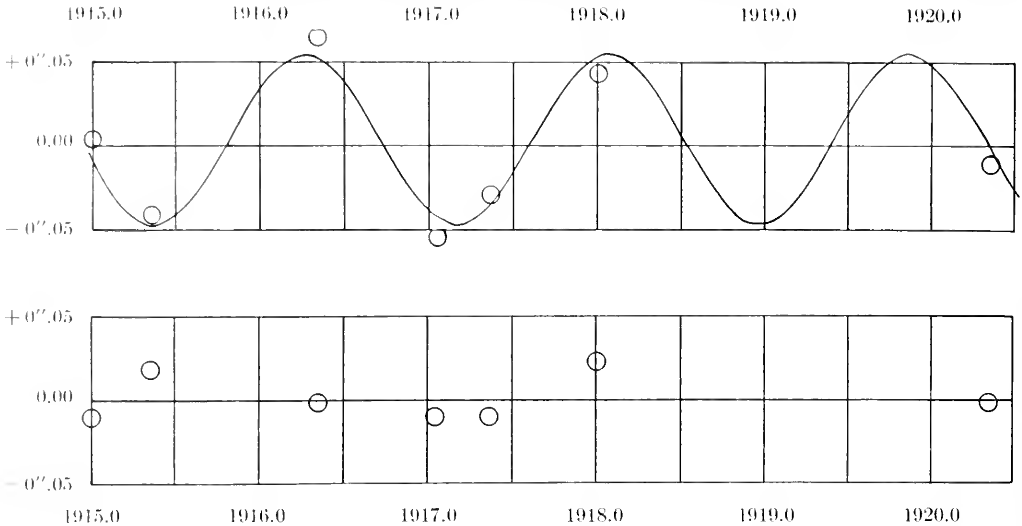


FIG. 1. Residuals from preliminary solutions. Brighter component above, fainter component below.

purely elliptical but showed perturbations with a period of 1.8 years, indicating that the orbital motion of the spectroscopic system has sufficient amplitude to be observed visually. HERTZSPRUNG[4] confirmed NÖRLUND's discovery by means of a large number of photographic observations made at Potsdam and showed that the motion could be well accounted for by supposing one of the visual components to be revolving in a small circular orbit of radius 0″.05 and inclination about 90°. The position angle of the major axis of the apparent ellipse is about 135°.

The determination of the parallax of this system given below is based on eighteen plates taken at the Allegheny Observatory and measured by the writer at the Yale Observatory. The preceding star, which is also the brighter, is No. 644 in the Allegheny parallax series; the following component is No. 645. The plates, which are described in Table I, were measured in right ascension and reduced according to the method of dependences, taking into consideration both the primary orbital motion of 59.8 years period and the secondary oscillation of the brighter component of 1.8 years period. The plate solutions (usually designated by m) were corrected for the long-period motion by means of NÖRLUND's elements and when thus corrected are designated by m'. They are contained in the eighth and eleventh columns of Table I. Three exposures were measured on each plate unless otherwise stated.

Three comparison stars were used, the rectangular coördinates of which referred to the parallax star are as follows: in X, −66mm., −26mm., +46mm.; in Y, −7mm., −69mm., +69mm. The dependences are .138, .424, and .438. The quantity +0.2002 mm. was added to the plate solutions for the brighter component in order to avoid the use of large numbers. The mean photographic magnitude of the comparison stars, estimated from the magnitudes of the parallax stars and the sector opening required to reduce their mean to apparent equality with the mean of the comparison stars, is 11.0.

Least-squares solutions were made for the parallax and proper motion of both components. The residuals, which are plotted in Figure 1, leave no doubt as to which star is affected by the secondary oscillation. Each circle in the diagram represents the weighted mean of all the plates of a single season. A sine curve of period 1.8 years and amplitude 0″.051 fits the residuals of the brighter star very well, as shown in the figure, confirming NÖRLUND's and HERTZSPRUNG's results, while the residuals of the fainter star are almost equally well satisfied by a straight line.

In order to free the parallax from the effect of this periodic motion, a second solution was made for the brighter star, introducing perodic terms. If we assume

[4] *Astronomische Nachrichten* 4976.

that the secondary orbit is circular, we may represent the projected motion in right ascension by sine and cosine terms, and the equations of condition will then have the form

$$c + a \sin\phi + b \cos\phi + t\mu + P\pi = m',$$

where ϕ is the phase angle reckoned from 1914.5 with a period of 1.8 years. The normal equations and their solutions for both stars are as follows:

No. 644. Brighter Component

$$\begin{aligned}
+15.30c \; +5.20a \; -1.47b \; + 44.06\mu \; - 3.97\pi &= +0.2266\\
+6.79 \; -0.55 \; + 24.62 \; + 0.33 &= +0.0168\\
+8.50 \; + 8.90 \; + 0.93 &= -0.0870\\
+812.79 \; -36.35 &= -4.7324\\
+ 9.71 &= +0.2044
\end{aligned}$$

$$\begin{aligned}
c &= +0.0393\\
a &= -0.00006\\
b &= +0.00362\\
\mu &= -0.00762\\
\pi &= +0.00823
\end{aligned}$$

Probable error for unit weight,
± 0.0013mm. = $\pm 0''.019$

Annual proper motion in R. A., $-0''.406 \pm 0''.0027$

Relative parallax, $+0''.120 \pm 0''.007$

No. 645. Fainter Component

$$\begin{aligned}
+15.30c \; + 44.06\mu \; - 3.97\pi &= +0.1257\\
+812.79 \; -36.35 &= -5.1251\\
+ 9.71 &= +0.2535
\end{aligned}$$

$$\begin{aligned}
c &= +0.0330\\
\mu &= -0.00759\\
\pi &= +0.0112
\end{aligned}$$

Probable error for unit weight,
± 0.0016mm. = $\pm 0''.023$

Annual proper motion in R. A., $-0''.404 \pm 0''.0034$

Relative parallax, $+0''.164 \pm 0''.008$

Other determinations of the parallax of this star are: Yale (heliometer), $+0''.179 \pm 0''.032$; Abetti (meridan circle), $+0''.128 \pm 0''.036$; Flint (meridian circle), $+0''.168 \pm 0''.031$; Mt. Wilson (spectroscopic), $+0''.126 \pm 0''.023$ for the brighter component, and $+0''.120 \pm 0''.022$ for the fainter; Greenwich (dynamical), $+0''.130 \pm 0.023$; Lockyer (spectroscopic), $+0''.110$. Boss gives for the proper-motion in right ascension, $-0''.421$.

When the coefficients of the periodic terms in the above solution (a and b) are expressed in seconds of arc, the secondary oscillation in right ascension of the brighter component is represented by the following expression:

$$0''.053 \cos(\phi + 1°)$$

Hertzsprung found $0''.037$ for the amplitude of this motion.

TABLE II

Date	Weight	Position Angle	Probable Error	Separation	Probable Error
		°	°	"	"
1915.00	2.5	113.3	±0.29	3.12	±0.018
15.35	2.0	114.2	.32	3.17	21
16.34	2.7	111.0	.29	2.99	18
17.03	1.3	110.0	.42	3.16	25
17.36	2.4	109.3	.31	3.06	19
18.00	1.4	107.7	.42	2.98	25
20.34	3.0	101.9	.29	2.88	17
21.18	2.0	100.7	.38	2.83	21

The plates used in the determination of the parallax, together with two later plates that were not received until the computations were well advanced, were measured in both right-ascension and declination. The measures in the two coördinates yield values of the position angle and separation of the visual pair, and these are listed in Table II. The plates of each parallax season are combined by weight to give a single value of the position angle and separation.

Yale University Observatory,
March 8, 1924.

THE INTER-RELATIONS OF THE ASTEROID ELEMENTS,

By SAMUEL G. BARTON.

The present paper is a slight extension of that contained in *A. J.* No. 702. The following misprints occur there: page 42, last line, for 776", read 766"; page 47, line 11, for 11 of 4°, read 10 of 4°; page 48, in the number column in the table for i, read 3 in place of 8 for inclination 26°.

The asteroids have since been arranged according to magnitude, g, for each 0.1 magnitude. The results are shown in the following table and in the graph. The values are plotted from $g = 7.0$ to $g = 10.5$. There are 57 asteroids with g less than 7.0, and 83 with g greater than 10.5. The values corresponding to these groups are indicated by the crosses. There are usually more asteroids for the even and half magnitudes than for the odd tenths, no doubt representing a prejudice on the part of the computer. ω shows a slight decrease with increasing g, corresponding to a decrease of ω with an increase of μ. The Ω-curve has a decided wave form not suggested in the plot in the Ω-curves. The reason is not apparent. i decreases with g except for large values of g. A similar relation is seen in the plot of the i-curves. The very small i for large g appears to be accidental. The μ-curve is very regular to $g = 10.0$, where there is a sharp increase in μ. The regular part seems to show that the large and small asteroids are scattered about uniformly. (See the discussion of the μ-curves on this point). The exclusion of the smaller asteroids from the outer parts of the zone explains the rise at the end.

SUMMARY FOR g

No.	m_0	g	π	ω	Ω	i	ϕ	μ	No.	m_0	g	π	ω	Ω	i	ϕ	μ
			°	°	°	°	°	″				°	°	°	°	°	″
2	7.0	4.0	200	108	92	8.8	4.8	874	18	12.8	9.1	195	182	133	9.8	10.2	738
1	8.0	4.5	122	309	173	34.7	13.8	769	26	12.9	9.2	129	201	163	9.9	7.4	737
3	9.2	5.4	113	241	230	10.4	9.6	698	24	13.0	9.3	190	194	102	8.0	6.9	728
1	8.7	5.5	56	245	171	13.0	14.8	813	19	13.0	9.4	159	183	184	8.6	6.5	756
2	8.4	5.8	29	189	200	10.2	12.4	951	24	12.8	9.5	189	214	170	8.2	6.9	814
2	11.1	5.9	181	264	97	12.6	8.0	505	19	13.1	9.6	170	178	163	9.0	8.6	755
2	9.6	6.0	8	273	95	9.4	5.8	739	17	13.2	9.7	163	183	192	7.7	8.1	769
2	9.4	6.1	57	206	212	9.9	5.0	792	15	13.2	9.8	163	129	202	9.0	8.1	770
2	10.2	6.2	71	323	107	11.2	10.0	687	9	13.7	9.9	103	157	186	5.9	11.5	692
4	9.8	6.3	141	101	133	11.7	7.0	760	16	13.2	10.0	119	152	192	6.6	7.5	853
4	11.1	6.4	194	131	239	15.8	9.0	567	8	13.4	10.1	173	189	164	5.0	8.5	809
6	10.2	6.5	124	197	166	11.8	7.2	742	17	13.4	10.2	205	169	163	8.4	9.7	849
8	10.2	6.6	84	199	154	12.9	10.6	739	9	13.2	10.3	200	153	167	10.7	8.4	885
7	10.5	6.7	143	179	169	8.8	7.9	704	10	13.6	10.4	208	137	208	11.8	8.5	844
6	10.7	6.8	59	223	136	12.0	7.5	706	14	13.7	10.5	186	162	179	10.4	10.9	830
5	9.9	6.9	159	275	172	8.3	7.3	871	5	13.1	10.6	166	126	184	11.3	10.5	1054
10	11.0	7.0	173	213	140	11.6	8.3	656	3	13.5	10.7	223	229	234	14.2	11.2	921
9	10.5	7.1	180	136	165	7.7	6.6	781	10	13.2	10.8	200	237	215	9.4	9.0	982
12	10.8	7.2	153	206	133	7.7	8.7	741	8	14.0	10.9	184	163	156	7.6	10.7	918
14	10.9	7.3	191	168	177	9.9	7.6	747	9	13.5	11.0	149	160	149	8.2	9.1	1006
14	11.0	7.4	186	184	156	9.1	9.0	746	6	13.7	11.1	81	108	153	9.0	11.2	965
11	11.1	7.5	114	209	199	9.5	7.6	710	6	13.8	11.2	154	118	96	8.5	12.0	982
13	11.0	7.6	211	209	223	12.3	8.7	779	3	13.8	11.3	215	204	132	4.4	7.9	983
21	11.6	7.7	194	174	209	9.2	8.6	701	5	14.3	11.4	156	179	194	11.3	13.5	898
18	11.3	7.8	192	235	196	10.5	8.6	775	4	14.0	11.5	203	206	86	10.0	11.0	985
10	11.4	7.9	198	112	200	10.9	8.7	777	3	14.1	11.6	48	184	103	7.5	8.5	949
24	11.7	8.0	153	195	168	10.1	9.7	727	2	14.1	11.7	21	156	225	2.2	5.7	1021
19	11.9	8.1	178	116	184	9.9	7.8	701	5	14.3	11.8	261	149	184	14.3	12.5	991
35	11.9	8.2	202	174	172	9.3	8.0	737	2	14.3	11.9	30	175	215	2.5	9.4	1013
20	11.9	8.3	162	172	178	12.0	8.6	717	2	14.3	12.0	101	71	210	5.0	9.7	1051
19	12.0	8.4	153	166	158	9.1	7.3	750	3	14.9	12.1	240	151	330	8.4	15.0	915
32	12.1	8.5	188	183	162	9.8	8.4	750	1	14.5	12.3	57	16	41	1.7	7.3	1072
19	12.4	8.6	161	217	153	11.1	7.9	714	2	14.5	12.4	354	51	302	3.3	11.7	1072
24	12.3	8.7	154	194	166	11.6	9.5	767	1	14.7	12.5	216	121	95	4.2	10.2	1055
37	12.2	8.8	216	155	178	10.4	7.2	782	4	15.5	12.8	47	203	204	11.6	14.6	935
19	12.4	8.9	196	195	172	9.4	8.1	776	1	16.7	13.1	139	47	93	3.2	1.2	737
44	12.7	9.0	165	175	161	9.2	7.5	726	1	17.6	14.5	338	152	186	10.8	32.7	854

The classification of the asteroids with respect to μ and i has been extended to include all asteroids available, 978 in all. The additional data was taken from *Kleine Planeten* for 1917 and *A. N.* Nos. 4972, 5030, 5077, 5143 and 5202. The small inclinations for large values of μ, mentioned in the previous discussion, are even more conspicuous with the larger number as many more asteroids are added in this region. HIRAYAMA in Appendix II of *Annales de L'Observatoire Astronomique de Tokyo* explains the peculiarity on the basis of the secular perturbations due to *Jupiter*. These asteroids constitute a large family, which he calls the *Flora* family. The asteroid region ends on the side of the sun with remarkable abruptness. The complete information is given in the following tables:

978 ASTEROIDS

SUMMARY FOR μ

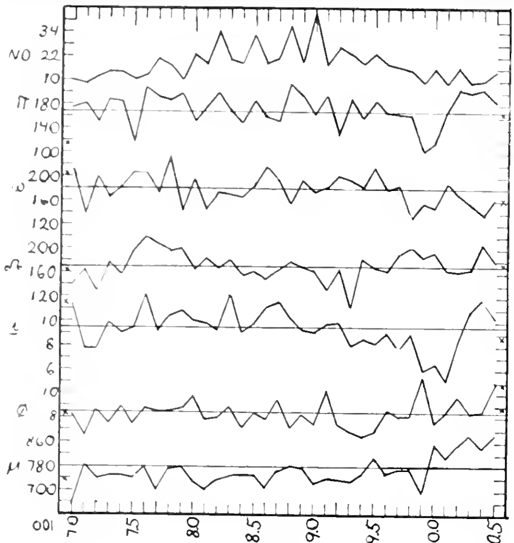
No.	π	ω	☊	i	φ	μ
	°	°	°	°	°	″
1	78	56	21	43.1	40.8	250
3	170	210	319	12.4	5.8	275
3	240	236	243	16.2	6.5	300
1	310	234	76	2.4	4.6	400
1	283	54	228	7.9	9.3	425
6	82	182	200	5.7	9.0	450
1	2	243	119	4.4	4.6	500
6	150	287	102	12.7	5.3	525
19	173	190	172	10.9	7.2	550
4	109	185	193	8.0	11.7	575
53	166	191	172	11.5	7.0	600
134	175	180	167	10.1	8.5	625
50	165	163	182	9.5	8.0	650
65	162	176	179	11.0	7.0	675
43	138	185	154	9.9	6.1	700
36	179	200	160	8.3	7.4	725
80	170	174	154	10.4	8.8	750
78	170	173	149	9.8	9.2	775
59	180	181	176	8.8	10.0	800
53	173	175	189	12.0	10.4	825
53	153	156	201	10.6	9.8	850
16	177	194	186	10.0	8.8	875
23	184	131	178	8.5	8.2	900
37	167	212	169	6.9	9.0	925
32	161	149	191	10.3	10.0	950
25	217	167	166	10.0	9.8	975
15	214	149	185	10.5	10.5	1000
15	203	191	155	5.5	7.6	1025
32	177	153	159	4.2	8.2	1050
22	193	181	176	4.3	8.5	1075
10	123	183	156	5.7	7.8	1100
1	298	123	175	22.5	4.2	1300
1	121	178	304	10.8	12.9	2000

SUMMARY FOR i

No.	π	ω	☊	i	φ	μ
	°	°	°	°	°	″
12	134	201	173	0	7.6	760
39	148	178	174	1	7.2	766
63	170	174	156	2	8.1	797
65	156	148	175	3	7.8	821
61	137	184	171	4	7.7	837
77	192	185	161	5	8.5	882
63	160	177	165	6	8.0	791
62	196	165	164	7	8.2	781
67	168	174	183	8	8.9	768
55	163	165	181	9	7.7	771
63	193	197	167	10	9.0	772
54	177	198	179	11	8.3	772
47	175	193	158	12	10.2	731
42	146	164	170	13	7.6	754
41	165	146	187	14	8.7	779
39	185	189	181	15	9.1	751
19	234	151	178	16	9.6	721
11	179	156	154	17	8.6	686
25	171	194	164	18	10.7	701
12	223	213	219	19	7.7	712
10	233	180	197	20	8.6	667
12	132	171	201	21	9.0	686
5	160	189	115	22	10.3	776
8	197	233	189	23	13.4	882
4	140	295	115	24	12.5	753
11	135	143	188	25	9.9	800
3	83	123	80	26	14.2	656
1	31	57	334	27	14.8	690
1	204	140	64	28	5.6	683
1	104	309	156	29	13.0	839
2	175	118	237	32	14.9	831
2	187	182	186	34	12.4	762
1	78	56	21	43	40.8	260

The distribution of the centers of the orbits, found by averaging $a \sin \phi$ for each 10° of π, is shown in the following table. The general average value of $a \sin \phi$ is 0.413. The relations to the perihelion of *Jupiter* mentioned in the previous discussion of the π-curves and those described by NEWCOMB,* appear clearly.

**Encyclopedia Britannica*, Vol. 21, page 718.



☊ CURVES

No.	π	$a \sin\phi$	No.	π	$a \sin\phi$	No.	π	$a \sin\phi$
44	0°	.46	24	120°	.33	16	240°	.35
52	10	.43	18	130	.34	27	250	.35
49	20	.46	24	140	.34	23	260	.35
37	30	.43	15	150	.31	21	270	.42
41	40	.49	17	160	.33	26	280	.45
36	50	.41	10	170	.29	19	290	.39
36	60	.42	10	180	.27	25	300	.49
25	70	.34	21	190	.29	40	310	.43
24	80	.49	14	200	.39	41	320	.43
31	90	.42	16	210	.38	44	330	.49
27	100	.39	15	220	.39	32	340	.47
19	110	.36	17	230	.30	42	350	.49

The average elements for the 978 asteroids are:

$$\pi = 171^\circ \qquad i = 9^\circ.6$$
$$\omega = 177^\circ \qquad \varphi = 8^\circ.6$$
$$\Omega = 171^\circ \qquad \mu = 781''$$

Flower Observatory, University of Pennsylvania,
Upper Darby, Pa.,
March 5, 1924.

OBSERVATIONS OF MINOR PLANETS,

MADE AT ANN ARBOR WITH THE 12¼ INCH REFRACTOR OF THE DETROIT OBSERVATORY,

By R. A. ROSSITER, O. L. DUSTHEIMER, L. A. SEARS, P. A. SMITH, AND H. F. SCHIEFER.

1922	G. M. T.	★	No. Comp.	Planet — ★ $\Delta\alpha$	Planet — ★ $\Delta\delta$	Planet's Apparent α	Planet's Apparent δ	Log $p\Delta$ for α	Log $p\Delta$ for δ	Obsr.
					(1) *Ceres*					
	h m s			m s	′ ″	h m s	° ′ ″			
Apr. 18	16 20 44.9	1	10, 10	+0 32.73	+ 7 41.7	14 23 12.13	− 0 36 32.0	9.368*n*	0.775	*R*
18	16 36 50.6	1	10, 10	+0 32.14	+ 7 46.1	14 23 11.54	− 0 36 27.5	9.245*n*	0.775	*Sm*
21	14 54 27.6	2	11, 11	−0 42.25	+ 8 19.2	14 20 36.48	− 0 30 1.0	9.500*n*	0.773	*R*
					(6) *Hebe*					
28	17 33 54.0	3	10, 10	+0 18.88	− 1 26.0	14 16 3.79	+ 9 7 41.0	8.213	0.682	*R*
29	14 27 46.5	3	10, 10	−0 27.29	+ 2 47.8	14 15 17.62	+ 9 11 54.9	9.481*n*	0.704	*R*
					(39) *Laetitia*					
July 21	17 12 54.9	4	12, 10	+0 27.94	+ 2 53.4	19 33 4.93	−10 16 42.5	7.492	0.842	*R*
21	17 44 29.3	4	11, 13	+0 26.84	+ 2 47.3	19 33 3.83	−10 16 48.6	8.765	0.842	*D*
24	15 59 27.8	5	10, 11	+0 10.59	− 2 33.1	19 30 38.35	−10 33 7.7	9.042*n*	0.842	*R*
24	16 22 23.7	5	12, 11	+0 9.68	− 2 38.9	19 30 37.47	−10 33 13.2	8.823*n*	0.843	*Se*
24	16 54 19.0	5	12, 16	+0 8.68	− 2 45.7	19 30 36.47	−10 33 20.0	8.043*n*	0.844	*D*
25	16 7 8.9	6	10, 10	+0 28.55	− 1 19.3	19 29 50.77	−10 38 52.9	8.939*n*	0.843	*D*
25	16 32 32.6	6	11, 10	+0 26.23	− 1 26.9	19 29 48.45	−10 39 0.5	8.582*n*	0.844	*Se*

1922	G. M. T.	★	No. Comp.	Planet — ★ Δα	Planet — ★ Δδ	Planet's apparent α	Planet's apparent δ	Log pΔ for α	Log pΔ for δ	Obsr.
				(39) *Laetitia* (*Continued*)						
	h m s			m s	′ ″	h m s	° ′ ″			
July 25	16 47 50.8	6	10, 10	+0 25.62	− 1 30.4	19 29 47.84	−10 39 4.0	7.936*n*	0.845	*R*
26	16 23 46.3	6	.., 5	......	+ 3 59.8	....	−10 33 33.8	...	0.844	*D*
26	16 34 39.3	6	11, ..	−0 33.32	....	19 28 48.92	....	8.497*n*	....	*D*
29	17 15 10.6	7	10, 11	−0 19.03	+ 7 22.3	19 26 36.59	−11 2 52.7	8.928	0.845	*Se*
29	17 40 39.8	7	14, 11	−0 19.85	+ 7 17.4	19 26 35.77	−11 2 57.6	9.122	0.843	*D*
29	18 2 12.9	7	13, 12	−0 20.39	+ 7 11.2	19 26 35.23	−11 3 3.8	9.225	0.841	*R*
30	15 18 21.1	8	10, 11	+0 7.26	− 2 7.9	19 25 54.78	−11 8 25.9	9.104*n*	0.844	*R*
30	15 30 50.4	8	10, 11	+0 6.75	− 2 11.3	19 25 54.27	−11 8 29.3	8.999*n*	0.845	*D*
30	16 33 45.1	8	12, 13	+0 4.74	− 2 27.7	19 25 52.26	−11 8 45.7	7.296*n*	0.847	*Se*
				(40) *Harmonia*						
Oct. 13	15 25 44.4	9	10, 10	−0 6.84	+ 5 29.2	0 37 52.11	− 4 17 50.9	9.171*n*	0.802	*R*
13	15 50 40.0	9	10, 10	−0 7.81	+ 5 24.2	0 37 51.14	− 4 17 55.9	9.011*n*	0.803	*Sc*
16	15 15 49.3	10	10, 11	−0 0.69	− 4 23.1	0 35 13.67	− 4 29 19.0	9.146*n*	0.803	*R*
16	15 42 32.0	10	11, 11	−0 0.92	− 4 29.4	0 35 13.44	− 4 29 25.3	8.960*n*	0.804	*Sc*
				(8) *Flora*						
30	16 57 29.3	11	9, 10	−0 39.95	+ 1 10.2	2 36 7.88	+ 2 35 12.2	8.864*n*	0.718	*Sc*
				(3) *Juno*						
Nov. 10	15 15 28.4	12	10, 10	−0 36.46	+ 0 57.0	3 20 5.41	− 3 47 34.2	9.402*n*	0.814	*Sc*

R. A. Rossiter = *R*, O. L. Dustheimer = *D*, L. A. Sears = *Se*, P. A. Smith = *Sm*, H. F. Schiefer = *Sc*.

Mean Places for 1922 of Comparison Stars

★	α	Red. to App. Pl	δ	Red. to App. Pl.	Authority
	h m s	s	° ′ ″	″	
1	14 22 37.11	+2.29	− 0 44 6.4	− 7.3	*A. G. Nicolajew* 3740
2	14 21 16.42	+2.31	− 0 38 12.9	− 7.3	*A. G. Nicolajew* 3737
3	14 15 42.66	+2.25	+ 9 9 13.6	− 6.6	*A. G. Leipzig II* 6665
4	19 32 33.76	+3.26	−10 19 53.1	+17.2	*A. G. Harvard* 6877
5	19 30 24.48	+3.28	−10 30 51.5	+17.2	*A. G. Harvard* 6865
6	19 29 18.93	+3.29	−10 37 50.8	+17.2	*A. G. Harvard* 6854
7	19 26 52.31	+3.31	−11 10 32.2	+17.2	*A. G. Harvard* 6836
8	19 25 44.21	+3.31	−11 6 35.2	+17.2	*A. G. Harvard* 6820
9	0 37 55.45	+3.50	− 4 23 40.9	+20.8	*A. G. Strassburg* 148
10	0 35 10.86	+3.50	− 4 25 16.7	+20.8	*A. G. Strassburg* 131
11	2 36 41.06	+3.77	+ 2 33 49.0	+13.0	*Albany* 743
12	3 20 38.13	+3.71	− 3 48 39.9	+ 8.7	*A. G. Strassburg* 811

Detroit Observatory, Ann Arbor Michigan,
February 8, 1924.
Communicated by R. A. Rossiter, Assistant Professor of Astronomy.

OBSERVATIONS OF ASTEROIDS,

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

By ERNEST CLARE BOWER.

[Communicated by CAPTAIN EDWIN T. POLLOCK, U. S. Navy, Superintendent.]

G. M. T.		App. α	App. δ	Obj. − ★		Comp.	log pρ		Ap. pl. red. of ★		Seeing	★
		1 Ceres										
		h m s	° ′ ″	s	′ ″				s	″		
1923 June	9.84871	21 18 21.87	−24 32 7.2	+40.42	+0 51.9	d10, 8	9.067n	0.891	+1.71	+17.2	p	1
	20.79346	21 17 42.07	−25 28 52.6	−15.79	+0 20.2	d10, 8	9.286n	0.886	+2.05	+18.6	p	2
	30.75649	21 11 31.33	−26 30 24.7	−29.18	−8 9.8	d10, 8	9.336n	0.886	+2.37	+19.5	f	3
July	7.71444	21 10 53.98	−27 16 56.1	+ 3.86	−1 52.9	d12, 10	9.154n	0.875	+2.55	+19.8	p	4
Aug.	7.67408	20 45 27.36	−30 26 2.5	+11.92	−4 15.9	d10, 8	8.969n	0.912	+3.18	+18.3	f	5
	13.66424	20 40 7.74	−30 50 14.7	−36.57	−5 4.5	d10, 8	8.772n	0.915	+3.24	+17.6	p	6
Sept.	1.57784	20 26 37.21	−31 28 14.4	+30.12	−5 5.5	d10, 9	9.156n	0.911	+3.19	+15.0	f	7
	11.60690	20 22 35.08	−31 25 56.6	−38.80	+3 51.4	d10, 8	8.737	0.916	+3.10	+13.8	g	8
	17.60096	20 21 25.08	−31 18 18.3	−26.56	+2 43.7	d10, 8	8.964	0.915	+3.02	+13.3	g	9
		2 Pallas										
1923 Apr.	9.81665	19 2 7.48	+14 25 33.5	− 3.21	−2 57.3	d10, 8	9.565n	0.629	+0.70	− 2.7	f	10
	10.85594	19 2 37.94	+14 36 1.8	− 5.23	+1 25.7	d10, 8	9.444n	0.594	+0.73	− 2.7	f	11
	16.83449	19 5 10.25	+15 36 27.1	−14.60	+1 31.1	d10, 9	9.470n	0.586	+0.86	− 2.5	p	12
		3 Juno										
1923 Apr.	26.55003	5 55 42.53	+14 6 45.0	− 8.16	−1 13.9	d10, 8	9.634	0.668	−0.07	−11.5	f	13

Mean Places of Comparison Stars for Beginning of Year

★	α	δ	Authority
	h m s	° ′ ″	
1	21 17 39.71	−24 33 16.3	*Cordoba A* 14724
2	21 17 55.81	−25 29 31.1	*Cordoba A* 14727
3	21 11 58.11	−26 22 34.1	*Cordoba A* 14701
4	21 10 17.57	−27 15 23.0	*Cordoba B* 13977
5	20 45 12.26	−30 22 1.9	*Cordoba B* 13714
6	20 40 11.04	−30 45 27.8	*Cordoba B* 13659
7	20 26 3.90	−31 23 23.9	*Astr Per* −32.2024, 335
8	20 23 10.78	−31 30 1.8	*Astr Per* −32.2021, 311
9	20 21 18.62	−31 21 15.3	*Astr Per* −32.2021, 343

★	α	δ	Authority
	h m s	° ′ ″	
10	19 2 10.02	+14 28 33.5	*Astr Bor* { +14.1904, 23 +15.1900, 373
11	19 2 42.41	+14 34 38.8	*Astr Bor* { +14.1904, 39 +15.1900, 388
12	19 5 23.99	+15 31 58.2	*Astr Bor* { +15.1900, 218 +15.1908, 12 +16.1904, 312
13	5 55 50.76	+14 8 10.4	*Astr Bor* { +14.0552, 353 +15.0556, 372

U. S. Naval Observatory, Washington, D. C.,
1924 March 6.

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FAINT STARS OF APPRECIABLE PROPER-MOTION,

MEASURED ON PLATES TAKEN WITH THE 26-INCH MCCORMICK REFRACTOR.

By HAROLD L. ALDEN AND P. VAN DE KAMP.

In the course of the measurement of over 1900 faint stars in the fields of Boss stars included in the McCormick parallax program, the following stars have been measured whose proper-motion is equal to or greater than ten seconds of arc per century. They are given here in advance of the detailed publication.

Relative proper-motions were derived from two or more pairs of plates separated by an average interval of 7.6 years. On the average six comparison stars were used for the determinations of the plate constants. Since the mean distance of the proper-motion stars from the center of the plate was 17′, errors in the plate constants will affect the relative proper-motions. The relative proper-motion in each case has been reduced to absolute proper-motion on the system of Boss' *Preliminary General Catalogue* by applying the difference between the absolute proper-motion of the Boss star and its relative proper-motion as found on the same plates. The catalogue motions were corrected for the quantities given on page XXVIII of the Introduction. The average probable error of the final proper-motion given below is ±0″.010 in each coordinate.

The following table gives the essential data regarding the stars. The first three columns give the serial, B. D., and *Draper Catalogue* numbers. Columns four and five give the right ascension and declination for 1900. These were obtained by applying to the position of the Boss star the measured difference in each coordinate. The next column contains the photovisual magnitude and spectral type. The latter has been taken from the *Draper Catalogue*, those in the last three hours of right ascension having been kindly furnished by Dr. Shapley in advance of publication. The magnitudes were derived from measurements of diameters of the star images and are on the *Harvard* system. The next four columns give the absolute proper-motion in right ascension and

No.	B. D.	H. D.	1900 R. A.	1900 Decl.	Mag. and Spectrum	Absolute Proper-motion R. A.	Absolute Proper-motion Decl.	Absolute Proper-motion Total	Absolute Proper-motion p	Boss No.	Meas. by	Remarks
	°		h m	° ′	m	″	″	″	°			
1	−25 221	3401	0 31.9	−25 2	7.8 G0	+0.008	−0.198	0.198	178	127	A	*a*
2	+30 89	.....	0 33.5	+30 28	9.6	− .223	− .071	.234	252	132	K	*a,b*
3	+30 96	3790	0 35.5	+30 31	8.0 F5	+ .141	+ .05:	.15:	71	132	K	*b*
4	+54 234	.....	1 4.3	+54 45	10.6	+ .170	− .018	.171	96	261	A	*a*
5	+14 229	.....	1 25.5	+15 3	11.4	+ .421	− .066	.426	99	335	K	..
6	−16 301	10785	1 40.4	−16 23	8.5 G0	+ .285	− .185	.340	123	391	A	*b*
7	+ 2 418	.....	2 37.3	+ 2 57	10.2	− .151	− .152	.214	225	622	A	*a,c*
8	+ 3 423	.....	2 57.8	+ 3 32	9.3	+ .104	− .018	.115	115	691	A	*a*
9	+41 1053	.....	4 58.4	+41 14	10.6	+ .100	− .108	.147	137	1204	K	*a*
10	....	.....	5 9.9	+45 45	10.3	+ .086	− .407	.416	168	1246	A	*d*
11	+ 5 1731	61127	7 32.8	+ 5 49	8.2 G0	− .175	− .159	.237	228	2008	A	..
12	+ 7 2031	.....	8 43.1	+ 6 51	10.3	+ .237	− .424	.486	151	2351	K	
13	+24 2210	.....	10 11.4	+24 9	10.5	− .086	− .053	.101	238	2730	K	*a*
14	+20 2465	.....	10 11.2	+20 22	10.0	− .490	− .026	.491	267	2742	A	*b*
15	−11 2916	91816	10 31.6	−11 23	7.9 K0	+ .11:	− .26:	.30:	152	2822	K	*b*

No.	B. D.	H. D.	1900 R. A.	1900 Decl.	Mag. and Spectrum	Absolute Proper-motion R. A.	Absolute Proper-motion Decl.	Absolute Proper-motion Total	p	Boss No.	Meas. by	Remarks
			h m	° ′	m	″	″	″				
16	+38 2288		11 48.8	+38 32	8.4	− .177	− .078	.193	246	3442	A	..
17	1 [illegible]128		13 1.5	− 5 40	11.0	.00	− .10:	.10:	181	3409	A	*a*
18	−17 3844	115559	13 12.8	−17 17	9.4 G0	− .123	− .144	.189	221	3448	A	*a,e*
19	−22 3557		13 13.8	−22 30	10.2	− .334	− .066	.340	259	3449	A	*a,f*
20	+ 4 2760		13 28.7	+ 4 25	11.0	− .025	− .096	.099	195	3506	A	...
21			15 24.5	+59 28	12.0	+ .008	− .138	.138	177	3936	A	*a*
22	+15 2945		15 42.6	+15 28	10.0	+ .16:	− .36:	.39:	156	4009	K	*a*
23	+16 2846		15 51.0	+16 8	10.2	− .003	− .110	.110	182	4055	A	..
24			15 52.0	+15 19	10.8	+ .057	− .157	.167	160	4055	A	..
25	+62 1476	148226	16 21.5	+61 55	8.8 G5	+ .138	+ .024	.140	80	4192	A	..
26	+27 2891		17 43.7	+27 50	9.8	− .149	− .208	.256	216	4497	A	*a,b*
27	−15 5634		20 15.9	−15 47	10.4	+ .101	− .083	.131	129	5216	A	*a*
28	+39 4464		20 19.3	+10 8	10.4	+ .042	+ .106	.114	22	5229	A	*a*
29			20 34.5	+14 27	10.6	+ .131	− .151	.202	140	5291	A	...
30	+15 4251	197913	20 41.5	+15 33	7.1 K0	+ .106	+ .101	.148	16	5335	A	*a*
31	+15 4251	197913	20 41.5	+15 33	8.2 K0	+ .109	+ .085	.138	52	5335	A	*a*
32	+15 4257	198409	20 43.0	+15 53	7.5 F8	+ .114	− .037	.120	108	5335	A	*a*
33	+62 1946		21 12.8	+62 25	9.6	+ .132	+ .294	.322	21	5480	A	..
34	−17 6339	206033	21 34.2	−17 1	9.7 K0	+ .017	− .166	.173	164	5562	K	*a*
35	+29 4712	215274	22 38.9	+29 34	7.7 G5	+ .237	+ .042	.241	80	5865	A	*a*
36			22 43.8	+24 8	10.4	+ .169	+ .015	.170	85	5885	A	...
37	+ 2 4646	..	23 11.4	+ 2 41	9.0	+ .129	+ .030	.132	77	5988	K	*a*
38	+ 5 5244	224660	23 51.6	+ 6 7	8.7 K5	− .022	− .178	.179	187	6156	A	*a*

declination, the total proper-motion and its position angle. The last three columns give the Boss number of the star by means of which the position and absolute proper-motion were determined, the initial of the measurer, and references to the notes that follow the table.

The magnitudes of the stars in this list range from 7.1 to 12.0. The spectral types which are known are all F5 or "later". Probably all the stars are dwarfs. Grouping the stars according to size of the total proper-motion, we have the following numbers and frequencies based on a total of 1905 stars measured.

Total Proper-motion	Number	Per cent	Mean Magnitude
0″.40 to 0″.50	4	0.2	10.5
0 .30 to 0 .40	5	0.3	9.2
0 .20 to 0 .30	6	0.3	9.4
0 .10 to 0 .20	23	1.2	9.6

The first three groups are probably complete. From this we conclude that, if the 1905 stars measured are representative of the whole sky, at least two per-cent of the stars between the magnitudes 8 and 11 have total proper-motions in excess of 0″.10 per year.

McCormick Observatory, University, Virginia,
April 10, 192[illegible]

REMARKS

a. Used as a comparison star for the McCormick determination of the relative parallax of the Boss star.

b. Proper-motions for the following stars have been found in Cincinnati Publications, 18.

No.	Cin. No.	$\mu_\alpha \cos\delta$	μ_δ	Total Cin.	Total McC.
2	79	−0″.203	−0″.110	0″.231	0″.234
3	88	+ .157	+ .021	.157	.15:
6	212	+ .278	− .179	.331	.340
11	1244	− .487	− .039	.490	.491
15	1279	+ .167	− .259	.308	.30:
26	2368	− .13:	− .21:	.25:	.256

c. Proper-motion same as that of γ *Ceti*. See article in this *Journal*.

d. Furuhjelm's companion to *Capella*. See *A. N.* 4715, 181.

e. Proper-motion is the same in direction but only one-eighth that of 61 *Virginis*. The motion is parallactic in direction but not in amount. May be moving in space parallel to 61 *Virginis*.

f. See *A. J.* 33, 168, 1921.

DISTANT COMPANION OF γ *CETI*.

By HAROLD L. ALDEN.

γ *Ceti* (1900: — R. A. 2^h $38^m.1$, Decl. $+2°$ $49'$) is a double star, Σ 299. The components are of magnitude 3.6 and 6.8 and separated by a distance of $3''$ in position angle 290°. The relative motion of the pair is very small so that the system belongs to the 61 *Cygni* class. According to the *Preliminary General Catalogue* of Boss, the proper-motion of the bright star is $-0''.144$ $\pm''.0018$ in right ascension and $-0''.152$ $\pm''.0016$ in declination.

On plates taken with the 26-inch McCormick refractor, it has been found that a star of photovisual magnitude 10.2 shares the motion of the Struve double. This star is $14'.0$ from γ *Ceti*, the position for 1900 being: — R. A. 2^h $37^m.3$, Decl. $+2°$ $57'$. It is B. D. $+2°$ 418. Two good plates taken on August 24, 1923 were compared with four early plates taken in August and September 1914 and 1915. The early plates were of poor quality and the opening of the rotating sector was not small enough to eliminate completely the effect of the fainter star of the close double. Only six comparison stars were available for the determination of the plate constants and their distribution was not such as to give very accurate values of these quantities. Under the circumstances the relative proper-motions from the various pairs of plates agree as well as could be expected.

The following table gives the essential data regarding the relative proper-motions, the weighted means, and the computed probable errors for both γ *Ceti* and the distant companion. The probable errors of the mean relative motions have been computed in each case from the four residuals and the assigned weights. The probable error of a proper-motion in one coordinate to be expected from the known probable error of a plate of unit weight, the weights of the plates, and the time interval is of the order of $\pm 0''.005$.

Plates	Interval Years	Weight	Relative Proper-motion: γ *Ceti* $\mu_\alpha \cos\delta$	γ *Ceti* μ_δ	Distant Companion $\mu_\alpha \cos\delta$	Distant Companion μ_δ
			$''$	$''$	$''$	$''$
14874 — 221	8.956	0.7	−0.106	−0.130	−0.121	−0.121
14875 — 222	8.956	0.7	.114	.144	.126	.125
14874 — 1586	7.997	1.0	.122	.120	.115	.113
14875 — 1635	7.956	0.9	.110	.112	.152	.141
Weighted mean			−0.121	−0.125	−0.128	−0.125
Probable error			± .0048	± .0045	± .0057	± .0042
Absolute proper-motion			−0.144	−0.152	−0.151	−0.152
Probable error			± .0018	± .0016	± .0077	± .0064

The absolute proper-motion of γ *Ceti* has been inserted in the table for comparison. The absolute motion of the distant companion has been obtained by applying to the relative motion in each coordinate the difference between the relative and absolute proper-motion of the Boss star. The proper-motions of γ *Ceti* and the distant star are equal within the limits of the probable errors. Since the direction of the motion is nearly at right angles to the parallactic motion, we have added reason for believing that the stars have a common motion in space. It seems quite probable therefore that γ *Ceti* is another of the triple systems of which ζ *Ursae Majoris* is the classical example.

Five parallaxes have been published for γ *Ceti*. The weighted mean of these gives an absolute parallax of about $0''.04$. Assuming this to be correct, the components of the close double are separated about seventy-five astronomical units. This is two and one half times the mean distance of the planet *Neptune* from the Sun. The third member of the system is distant 21,000 astronomical units or one third of a light-year. The absolute magnitudes of the stars are 1.6, 4.8, and 8.2. According to the *Draper Catalogue*, the brightest star is of spectral type *A2*. The absolute magnitudes of the fainter stars correspond to dwarf stars of spectral types *G* and *K* or *M*, on the assumption of normal mass and luminosity.

The faint star was used as a comparison star at the Allegheny and McCormick Observatories for deriving

the parallax of γ *Ceti*. Since its parallax is probably of the same order of size as that of γ *Ceti*, the reduction from relative to absolute parallax for these two determinations is larger than the quantity usually applied.

McCormick Observatory, University, Virginia,
April 10, 1924.

OBSERVATIONS OF *EROS*,

WITH THE 10-INCH REFRACTOR OF THE YERKES OBSERVATORY,

By G. VAN BIESBROECK.

1923-24	G.M.T.	$\Delta\alpha$	$\Delta\delta$	n	α app.	δ app.	Parall.		★
	h m s	m s	′ ″		h m s	° ′ ″			
Oct. 19	19 19 35	−3 53.69	+2 38.1	25-5	7 58 53.52	+37 43 43.9	9.743n	0.528	1
Oct. 23	20 57 54	−5 30.12	−1 37.2	25-5	8 15 50.06	36 54 9.1	9.592n	0.310	2
Nov. 9	19 55 39	−0 12.38	−0 33.5	8 8	9 23 35.86	31 42 28.2	9.653n	0.537	3
Nov. 19	19 44 20	+0 3.96	−3 1.0	8 8	10 0 18.94	27 20 29.0	9.633n	0.585	4
Nov. 27	21 25 23	−1 41.18	−1 3.6	25-5	10 27 54.97	23 9 44.9	9.461n	0.535	5
Dec. 5	22 29 9	+1 42.58	−4 45.7	20 4	10 53 34.94	+18 28 41.5	9.182n	0.567	6
Jan. 8	22 7 49	+1 41.77	−3 42.3	25 5	12 22 5.55	− 5 17 46.7	9.035n	0.814	7
Jan. 16	23 54 21	+2 3.15	−2 35.7	20 4	12 38 22.47	−11 20 41.4	9.087	0.847	8
Jan. 23	22 1 29	+0 28.79	−2 45.9	25 5	12 50 44.10	−16 28 53.8	8.819	0.875	9
Jan. 29	22 31 38	+0 57.60	−2 39.9	25 5	13 0 6.27	−20 50 53.9	8.332	0.894	10
Feb. 13	21 23 10	+3 53.29	−0 13.9	25 5	13 16 19.19	−30 55 21.6	8.513	0.925	11

Comparison Stars

★	1923.0 − 1924.0		loc. app.		Authority
	h m s	° ′ ″	s	″	
1	8 2 44.95	+37 40 55.4	+2.26	−49.7	*A. G. Lu.* 4406.
2	8 21 17.97	36 56 6.6	2.21	−20.3	*Prager* 3438.
3	9 23 46.07	31 43 23.6	2.17	−21.9	*Prager* 3514.
4	10 0 12.38	27 23 52.2	2.17	−22.0	*Abbadia* 6035.
5	10 29 3.95	23 44 10.5	2.20	−22.0	*Abbadia* 6035.
6	10 51 50.08	+18 33 48.8	+2.25	−21.6	*Abbadia* 6474.
7	12 20 50.82	− 5 13 36.9	−0.04	+ 2.5	*A. G. Strb.* 4576.
8	12 36 19.14	−11 18 9.2	+0.18	3.5	*A. G. Harv.* 4582.
9	12 50 14.94	−16 28 53.8	0.37	4.3	*Hyder. ph.* −17°35074.
10	12 59 8.14	−20 48 18.9	0.56	4.9	*A. G. Alg.* 5642.
11	13 12 25.57	−30 55 13.1	+0.91	+ 5.4	*Gou. Z.* 13ʰ590.

Remarks

The object was located by means of the ephemeris supplied by F. SEAGRAVE (*P. A.* Vol. 31, p. 602 and Vol. 32, p. 61). After the last date it was considered as too far south for accurate measurement.

Estimated brightnesses: Oct. 19 and 23 = $11^m.5$ (☾); Nov. 9 = 10^m; Dec. 5 = 10^m; Jan. 16 = $9^m.5$; Jan. 23 = 10^m; Feb. 13 = $9^m.5$.

Williams Bay, Wisconsin,
March 10, 1924.

OCCULTATIONS BY THE *MOON*, 1923,

OBSERVED WITH THE 26 AND 12-INCH REFRACTORS OF THE U. S. NAVAL OBSERVATORY,

By ASAPH HALL AND ERNEST CLARE BOWER.

[Communicated by CAPTAIN EDWIN T. POLLOCK, U. S. Navy, Superintendent of U. S. Naval Observatory.]

Date	Object	Phen.	26-Inch						12-Inch					
			W. Sid. T.	W. M. T.	See'g	Pow'r	Obs	Rem.	W. Sid. T.	W. M. T.	See'g	Pow'r	Obs	Rem.
1923			h m s	h m s					h m s	h m s				
Jan. 10	6*B Lib*	DB	13 46 15.4	18 26 26.6	*f*	183	HL	sd	13 46 15.4	18 26 26.6	*p*	160b	B	± 10 f
12	VENUS	RD	14 45 24.8	19 17 34.5	*p*	183	HL	115 h		...				
19	150*B Aqr*	DD	2 22 44.8	6 29 24.8	*p*	183	HL	k	2 22 44.8	6 29 24.8	*p*	115	B	11
29	26 *Gem*	DD	11 46 57.2	15 12 45.7	*p*	183	HL	12 c	...			.		
30	162*B Gem*	DD	7 24 52.4	10 47 27.9	*g*	183	HL	11	7 24 52.6	10 47 28.2	*f*	115	B	12
30	162*B Gem*	RB	8 9 19.5	11 31 47.7	*g*	183	HL	120 se	8 9 18.1	11 31 46.3	*p*	160b	B	130 ± 20 fe
Feb. 23	70 *Tau*	DD	9 48 58.2	11 36 18.4	*p*	183	HL	k		..				
Mar. 4	91*G Vir*	RD	10 41 20.5	11 53 38.9	*p*	183	HL	12 w		.				
20	25 *Ari*	DD	7 37 42.5	7 47 36.4	*p*	183	HL	k	7 37 12.7	7 47 36.7	*p*	196	B	11½ k
24	130 *Tau*	DD	8 19 9.7	8 43 8.4	*f*	183	HL	k	8 49 9.8	8 43 8.5	*f*	115	B	11 k
24	130 *Tau*	RB	10 2 30.3	9 56 16.9	*f*	183	HL	110	10 2 29.1	9 56 15.7	*p*	160b	B	130 ± 20
28	ξ *Leo*	DD	10 17 41.6	10 25 37.2	*p*	183	HL	12		...		.		
29	48 *Leo*	DD	14 7 0.3	13 40 27.3	*p*	183	HL	11	14 7 0.3	13 40 27.3	*p*	196	B	11 e
May 1	49 *Lib*	DB	14 54 10.5	12 17 44.9	*p*	183	HL	u e		.				
1	49 *Lib*	RD	16 11 43.1	13 35 4.7	*p*	183	HL	h	16 11 13.1	13 35 4.8	*p*	160b	B	11
2	90*B Oph*	DB	13 33 51.3	10 53 43.0	*p*	183	HL	u	.	.				
2	90*B Oph*	RD	14 41 45.8	12 1 26.4	*f*	183	HL	11	14 11 15.8	12 1 26.3	*p*	160b	B	11½
4	187*B Sgr*	DB	...	.....		..		.	17 16 39.0	14 57 57.4	*f*	160b	B	± 5
4	187*B Sgr*	RD	....	....	.	..			19 12 3.4	16 23 7.8	*f*	115	B	12
19	110*B Gem*	RB	11 38 17.1	7 51 37.2	*g*	183	HL	110	.	...				
June 1	267*B Sgr*	DB	17 23 58.1	12 45 14.8	*p*	183	HL	u h	17 23 57.5	12 45 14.2	*p*	160b	B	± 20
1	267*B Sgr*	RD	18 45 56.5	14 6 59.7	*f*	183	HL	11 h	18 45 56.7	14 6 59.9	*p*	115	B	11½
22	θ *Vir*	RB	16 39 16.0	10 38 35.8	*p*	183	HL	120	....	.....		.		....
25	49 *Lib*	DD	14 9 34.3	7 57 1.0	*f*	183	HL	11	14 9 34.3	7 57 1.0	*p*	115	B	11
July 9	γ *Tau*	RD	23 13 52.2	16 4 47.0	*p*	183	HL	12 e sd	23 13 52.0	16 4 46.7	*f*	115	B	11
18	27*B Vir*	DD	15 32 47.6	7 49 34.7	*p*	183	HL	11	15 32 17.6	7 19 34.7	*p*	115	B	12
18	27*B Vir*	RB	15 50 46.5	8 7 30.6	*p*	183	HL	120	15 50 15.5	8 7 29.6	*p*	115	B	140 ± 20 A
19	38 *Vir*	RB	16 0 49.5	8 13 36.0	*p*	183	HL	120	....	....		.	.	...
26	267*B Sgr*	RB	16 13 0.0	7 58 13.2	*vp*	183	HL	vl	....	...		.	.	.
27	61*B Cap*	DB	19 12 29.6	10 53 17.4	*p*	183	HL	h	19 12 29.1	10 53 17.0	*p*	160b	B	± 20
27	61*B Cap*	RD	20 37 47.1	12 18 21.0	*f*	183	HL	120	. .	..		.	.	.
Aug. 30	39*B Ari*	DB	21 40 39.0	11 7 21.8	*f*	183	HL	h	21 40 10.7	11 7 23.4	*f*	160b	B	± 20
30	39*B Ari*	RD	22 53 29.3	12 20 0.1	*g*	183	HL	11 h	22 53 29.5	12 20 0.3	*g*	115	B	11
30	64 *Cet*	DB	2 47 28.1	16 13 20.6	*g*	183	HL	e2 B	2 17 30.2	16 13 22.7	*g*	160b	B	± 5
30	64 *Cet*	RD	4 10 3.3	17 35 42.3	*f*	183	HL	u B	.	.			.	
Sept. 2	71 *Tau*	RD	......	....		...	.	.	22 19 3.7	11 33 52.4	*p*	115	B	11 k
2	θ^2 *Tau*	DB	22 32 57.7	11 47 44.2	*p*	183	HL	...	22 32 57.6	11 47 44.1	*p*	160b	B	± 10

Date	Object	Phen	26-Inch W. Sid. T.	W. M. T.	See'g	Pow'r	Obs	Rem	12-Inch W. Sid. T.	W. M. T.	See'g	Pow'r	Obs	Rem
1923			h m s	h m s					h m s	h m s				
2	θ^2 *Tau*	RD	23 34 22.3	12 18 58.7	*p*	183	Hl	c	23 34 22.3	12 18 58.7	*f*	115	B	l2 c
2	θ^1 *Tau*	DB	22 37 17.7	11 52 33.3	*p*	183	Hl		22 37 18.2	11 52 33.8	*p*	160b	B	±10
2	θ^1 *Tau*	RD							23 28 19.0	12 43 26.3	*f*	115	B	l2 c
2	264*B Tau*	RD	0 25 37.4	13 40 5.1	*f*	183	Hl	c	0 25 37.8	13 40 5.8	*f*	115	B	l2 c
2	*α Tau*	DB							3 15 32.9	16 29 33.1	*p*	115	B	±40 c
29	18 *Tau*	DB	2 5 43.4	13 33 15.6	*p*	183	Hl							
29	18 *Tau*	RD	3 1 16.0	11 29 9.0	*f*	183	Hl	l1						
29	*γ Tau*	DB	5 22 20.8	16 19 50.7	*f*	183	Hl							
29	*γ Tau*	RD	6 2 46.5	17 30 9.8	*f*	183	Hl	l2						
Oct. 2	71*B Gem*	DB	1 57 9.1	13 13 21.9	*p*	183	Hl							
2	71*B Gem*	RD	2 24 46.2	13 40 57.5	*f*	183	Hl	l1						
17	61*B Cap*	DD	19 57 46.2	6 16 2.4	*g*	183	Hl	k						
17	61*B Cap*	RB	21 24 8.6	7 12 10.6	*f*	183	Hl	l20						
20	*φ Aqr*	DD	22 31 11.0	8 10 13.7	*f*	183	Hl	l1						
20	*φ Aqr*	RB	0 2 15.9	10 8 4.3	*f*	183	Hl	l20						
27	318*B Tau*	DB	8 33 28.8	18 10 22.0	*p*	183	Hl	sd						
Nov. 2	*A Leo*	DB	7 0 11.3	16 13 11.4	*g*	183	Hl		7 0 11.4	16 13 11.5	*g*	160b	B	l2½ r
2	*A Leo*	RD	8 0 11.8	17 13 35.0	*g*	183	Hl	l2 k	8 0 12.0	17 13 35.2	*g*	115	B	l1½ k
3	*c Leo*	DB	6 30 25.7	15 40 7.8	*p*	183	Hl		6 30 25.6	15 40 7.7	*p*	160b	B	±20
3	*c Leo*	RD	7 23 27.0	16 33 0.4	*f*	183	Hl	l2 k	7 23 27.3	16 33 0.7	*f*	115	B	l2½ k
20	39*B Ari*	RD	23 0 21.0	7 1 26.4	*f*	183	Hl	l2	23 0 21.1	7 4 26.4	*f*	160b	B	l1½
20	39*B Ari*	RB	0 18 43.6	8 22 36.0	*g*	183	Hl	l20	0 18 38.8	8 22 31.3	*f*	160b	B	l30±10
20	61 *Cet*	DD	4 19 31.7	12 22 14.7	*f*	183	Hl	l2	4 19 31.6	12 22 14.7	*f*	160b	B	l2
20	ξ^1 *Cet*	DD	5 43 22.1	13 16 21.4	*f*	183	Hl	l1	5 43 22.4	13 16 21.7	*f*	160b	B	l2
20	ξ^1 *Cet*	RB	6 44 57.3	14 17 16.5	*f*	183	Hl	l10	6 44 56.2	14 17 15.4	*p*	160b	B	l10±20
21	115 *Tau*	DB	5 29 14.8	13 17 2.6	*p*	178b	B	±20						
21	115 *Tau*	RD	6 54 39.0	14 41 13.0	*p*	178b	B	l2						
Dec. 12	151*B Cap*	DD	22 24 45.4	5 2 26.5	*f*	183	Hl		22 24 45.5	5 2 26.6	*g*	115	B	l1
12	151*B Cap*	RB	23 43 9.5	6 20 37.8	*f*	183	Hl	l20						
18	85 *Cet*	DD	4 51 21.6	11 1 23.9	*f*	183	Hl							
18	85 *Cet*	RB	6 5 48.4	12 18 38.5	*f*	183	Hl	l10						
24	*f Gem*	DB	1 35 1.0	7 25 3.1	*vp*	183	Hl							
24	*f Gem*	RD	2 35 23.4	8 25 12.6	*f*	183	Hl	l2	2 35 23.4	8 25 12.5	*p*	160b	B	l2

Ph.: DD = disappearance dark limb; DB = disappearance bright limb; RD = reappearance dark limb; RB = reappearance bright limb.

Power: b = occulting bar attached to eyepiece.

Obs.: Hl = Hall; B = Bower.

Remarks: c = cloudy; d = daylight; e = early; f = star faint; h = hazy; k = dark limb visible; l = late, r = good disappearance or reappearance; s = some, a little; u = uncertain; w = windy. Numbers are estimates in tenths of seconds. A. Saw D earlier than given time. B. Foggy.

The clock corrections used after 1923, Jan. 1 are based on the correction to star places given in the *American Ephemeris* 1925, p. 750.

U. S. Naval Observatory, Washington, D. C., 1924, Jan. 29.

OBSERVATIONS OF ASTEROID 1923 PE (*REINMUTH*),

By G. VAN BIESBROECK.

a) VISUAL OBSERVATIONS WITH THE 40-INCH REFRACTOR

1923	G.M.T.	$\Delta\alpha$	$\Delta\delta$	n	α app.	δ app.	Parall.		★
		m s	′ ″		h m s	° ′ ″			
Nov. 21	19 46 33	+0 4.81	−3 49.5	4 4	1 32 26.48	+11 12 27.0	9.603	0.723	1
Nov. 28	18 22 12	−0 33.37	+1 20.9	30 6	1 41 9.28	8 12 3.1	9.517	0.720	2
Dec. 10	16 9 36	−1 19.83	−1 11.0	8 8	1 59 17.17	4 18 16.2	9.434	0.736	3
Dec. 13	13 40 7	−2 42.49	−0 39.5	25 5	2 4 13.91	3 37 27.2	8.985n	0.744	4
1924									
Jan. 7	12 48 38	+0 5.60	+5 11.0	6 6	2 52 20.90	+ 1 2 10.0	8.991n	0.718	5

Comparison Stars

★	1923–1924		Red. to App.		Authority
	h m s	° ′ ″	s	″	
1	1 32 21.17	+11 16 0.0	+3.50	+16.5	*Tou. ph* +11°, 1h32m *Nr.* 22.
2	1 41 39.20	8 10 27.5	3.45	+15.0	*A. G. Lpz. II* 664.
3	2 0 33.60	4 19 15.3	3.40	+14.9	*Abbadia* 974.
4	2 6 52.84	3 37 55.6	3.39	+14.4	*A. G. Lpz. I* 606.
5	2 52 14.96	+ 0 57 8.2	+0.34	− 9.2	*Alger ph.* 0°, 2h48m *Nr.* 84.

b) PHOTOGRAPHIC POSITIONS WITH THE 24-INCH REFLECTOR

1923-24	1923.0-1924.0 α	δ	Parall.		Comparison Stars
	h m s	° ′ ″			
Nov. 10.67853	1 21 31.44	+16 53 40.5	8.560	0.578	Bord. ph +17°, 1h 24m, Nrs. 63, 65, 68.
Nov. 11.66669	1 22 18.99	16 21 43.7	7.946	0.586	Bord. ph +16°, 1h 20m, Nrs. 25, 29, 34.
Nov. 24.54654	1 35 36.69	9 57 55.8	9.376n	0.689	Tou. ph +9°, 1h 32m, Nr. 35.
Dec. 6.72350	1 53 1.40	5 24 54.8	9.443	0.734	Tou. ph +5°, 1h 48m, Nrs. 40, 44, 79.
Jan. 1.56127	2 40 6.67	+ 1 14 29.5	8.666n	0.762	*Abbadia* 1293, 1297, 1305.
Jan. 5.57205	2 48 16.89	1 4 45.4	7.368n	0.763	Alger ph 0°, 2h 48m, Nrs. 31, 41, 49.
Jan. 26.62461	3 33 21.10	1 46 51.3	9.309	0.759	*A. G. Albany* 1037.
Jan. 26.64127	3 33 23.47	1 46 55.3	9.385	0.760	*A. G. Albany* 1037.
Feb. 24.62211	4 38 40.28	4 29 1.2	9.444	0.741	Tou. ph +5°, 4h 36m, Nrs. 192, 197, 205.
Feb. 24.64572	4 38 43.77	4 29 8.7	9.508	0.745	Tou. ph +5°, 4h 36m, Nrs. 192, 197, 205.
Feb. 25.56962	4 40 50.26	4 34 36.0	9.191	0.734	Tou. ph +5°, 4h 36m, Nrs. 225, 236, 239.
Feb. 25.59392	4 40 53.84	4 34 45.0	9.333	0.737	Tou. ph +5°, 4h 36m, Nrs. 225, 236, 239.

Remarks

On account of its unusual motion at discovery this object was suspected at first of being cometary. With the 40-inch it was always seen as a star-like image, without any nebulosity. On Nov. 11, I made a 30 min. exposure with the 24-inch reflector and moved the plate so as to allow for the motion of the object. The resulting strong clear-cut image does not show any trace nebulosity.

For the observations in January and February I had the advantage of very close ephemeris positions communicated before publication by PROF. A. LEUSCHNER.

Visual estimations of brightness: Nov. 21 = 13.0; Nov. 28 = 13.5; Dec. 13 = 14.0; Jan. 7 = 15.0.

Photographic magnitudes from a rough comparison with the polar sequence: Nov. 10 = 13.5; Nov. 11 = 13.6; Nov. 21 = 14.1; Jan. 1 = 15.0; Jan. 5 = 15.6; Jan. 26 = 15.8; Feb. 24 = 16.6; Feb. 25 = 16.4.

On Nov. 21 the measures were difficult on account of the vicinity of the moon and haziness of the sky.

On Jan. 26, Feb. 24, and 25 the plate was moved so as to follow the asteroid (exposures 20, 30 and 33 minutes). This made the settings on the trailed comparison stars less accurate, especially in right ascension, but it had to be done for strengthening the image of the asteroid.

Yerkes Observatory, Williams Bay, Wisconsin,
March 5, 1924.

OBSERVATIONS OF COMET 1922 *c* (BAADE),

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

By ERNEST CLARE BOWER.

[Communicated by CAPT. EDWIN T. POLLOCK, U. S. Navy, Superintendent.]

G. M. T.	App. α	App. δ	Obj. ★		Comp.	Log pρ		Ap. pl. red. of ★		Seeing	★
1923	h m s	° ′ ″	s	′ ″				s	″		
Sept. 17.89513	1 43 18.65	+2 22 18.6	−2.17	+1 16.7	d13,11	8.878n	0.717	+2.16	+3.5	g	1
Nov. 9.75106	1 26 18.36	−6 39 11.5	−11.98	+1 46.1	d12,12	8.593n	0.796	+3.27	+3.8	g	3
Dec. 1.69171	1 41 52.24	−9 8 15.9	−4.62	−1 39.4	d12,12	6.731	0.844	+3.50	+1.5	g	4

Sept. 17 Very faint last half of observation. Nov. 9 13ᵐ.5. Very faint. Dec. 1. 11ᵐ. Very faint.

Mean Places of Comparison Stars for Beginning of Year

★	α	δ	Authority
	h m s	° ′ ″	
1	1 43 18.66	+2 18 28.4	Anon. comp. with 2, 1923 Oct. 31, $\Delta\alpha = +2^m 29^s.75$, $\Delta\delta = -11'18''.2$, 1923.0.
2	1 41 18.91	+2 29 46.6	*AG Albany* 1396.
3	1 26 27.07	−6 41 1.1	*Astr Ges* − 6.0124, 159.
4	1 41 53.36	−9 6 38.0	*BD* −9.857 comp. with 5, 1923 Dec. 1, $\Delta\alpha = +1^m 10^s.83$, $\Delta\delta = -3'50''.5$, 1923.0.
5	1 40 42.53	−9 2 17.5	*AG Wien-Ottakring* 1053.

U. S. Naval Observatory, Washington, D. C.,
1924 April 10.

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MEASURES OF DOUBLE STARS DISCOVERED SINCE 1905,

MADE AT THE LILLE OBSERVATORY AND AT THE ROYAL OBSERVATORY, GREENWICH.

By ROBERT JONCKHEERE.

The present paper is a continuation of the series of measures begun in the *Astronomical Journal* No. 753.

The reference numbers are those of the Catalogue published by the *Royal Astronomical Society* in 1917, which is, in effect, an extention of *Burnham's General Catalogue*. The measures marked *V* and *D* were made by Messrs. J. Vanderdonck and L. DeJaegher respectively.

A few new pairs are included here in addition to those published in *A. J.* 765. It is the author's intention to continue the work interrupted by the German occupation, and to begin a new survey of the sky to complete the knowledge of double stars to the fainter B. D. stars.

J.C.	Name	R.A.	Decl.	*p*	*d*	Mags.	1900+	Obs.	n.
		h m s	° ′	°	″				
6	J 143	0 1 55	12 49	85.6	1.99	9.5 – 9.8	21.89	J	3
				84.6	2.18	9.5 – 9.8	21.89	V	3
22*	J 867	0 6 48	28 17	185.5	1.17	8.9 – 11.6	21.89	J	3
				183.7	1.40	9.1 – 11.6	21.89	V	3
69	J 168	0 25 30	19 51	171.5	0.92	9.2 – 9.2	21.89	J	3
				170.7	1.20	9.3 – 9.3	21.89	V	3
	h 1976			262.3	12.60	9.2 – 11.2	21.89	J	3
				264.9	12.73	9.3 – 11.2	21.89	V	3
109	J 223	0 44 58	10 19	97.1	1.08	9.5 – 9.8	21.93	J	3
				96.9	1.08	9.6 – 9.6	21.93	V	3
236	J 228	1 32 43	23 30	102.6	3.23	8.7 – 10.6	19.31	J	3
				102.2	3.08	8.8 – 11.0	22.01	V	1
240*	J 587	1 33 54	22 8	27.0	1.36	9.7 – 9.7	16.90	J	1
				21.8	1.23	9.5 – 9.6	22.66	J	3
				25.0	1.47	9.6 – 9.7	22.66	V	3
246	J 927	1 36 12	14 44	244.9	3.92	10.1 – 11.0	20.34	J	3
				244.2	3.50	9.8 – 10.0	22.03	V	1
268	J 641	1 43 45	9 20	245.0	5.04	9.2 – 11.2	19.50	J	2
				242.6	5.08	9.3 – 12.0	22.10	V	1
269	J 642	1 43 53	26 49	125.8	1.51	9.5 – 9.9	16.90	J	1
				124.3	1.09	9.4 – 10.2	22.06	J	2
				124.9	1.23	9.5 – 10.0	22.06	V	2
283	J 671	1 48 30	21 28	155.8	2.77	9.6 – 9.7	16.90	J	1
				155.6	2.77	9.6 – 9.8	22.06	J	2
				153.5	2.63	9.6 – 9.9	22.06	V	2

[illegible]	Name	R. A.	Decl.	p	d	Mags.	1900+	Obs.	n.
		h m s	° ′	°	″				
298	J 346	1 52 18	12 5	251.1	2.47	9.6 – 11.0	16.90	J	1
				250.0	2.76	9.5 – 11.0	23.47	J	2
				250.5	2.61	9.5 – 10.8	23.17	V	2
302	J 643	1 53 3	14 8	173.2	3.62	9.2 – 10.5	16.90	J	1
				170.7	1.15	9.2 – 10.7	23.38	J	2
				167.0	3.42	9.1 – 10.5	23.38	V	2
306	J 230	1 55 14	21 11	156.0	2.65	9.2 – 9.2	17.87	J	1
				154.0	2.49	9.3 – 9.3	22.02	J	2
				149.9	2.57	9.4 – 9.2	22.02	V	2
366	Ait 2330	2 23 56	17 4	352.0	0.86	9.0 – 9.0	17.42	J	1
				354.4	0.96	9.0 – 9.0	22.13	J	2
				351.4	0.98	9.4 – 9.4	22.13	V	2
372	J 6	2 24 32	59 4	135.2	2.46	8.9 – 10.6	22.46	J	2
				135.8	2.22	8.9 – 10.6	22.46	V	2
537	26	3 37 46	15 0	147.1	2.45	9.2 – 9.2	22.01	J	3
				146.6	2.64	9.4 – 9.4	22.01	V	3
569	J 27	3 42 6	28 10	55.0	3.88	9.5 – 12.4	22.96	J	2
				56.8	3.64	9.5 – 12.5	22.96	V	2
577	J 28	3 46 45	28 32	188.8	2.84	9.6 – 11.8	22.96	J	2
				186.3	2.40	9.6 – 11.6	22.96	V	2
595	J 306	3 53 9	21 44	87.5	1.75	8.9 – 9.3	22.03	J	3
				87.0	2.06	9.0 – 9.2	22.05	V	2
610	J 30	3 58 47	6 29	231.3	1.52	9.5 – 11.5	23.08	J	2
				230.6	1.50	9.8 – 11.3	23.08	V	2
729	J 714	4 49 37	– 3 40	171.8	2.40	9.8 – 10.4	22.16	J	2
				170.8	2.40	9.6 – 10.2	22.16	V	2
	J 1348	4 50 11	– 3 5	94.5	4.76	9.3 – 9.4	22.62	J	2
	BD – 3 931			92.3	4.74	9.3 – 9.5	22.62	V	2
733*	J 712	4 50 54	– 3 41	167.7	1.95	9.2 – 9.7	22.62	J	2
				166.5	1.90	9.3 – 10.2	22.62	V	2
752*	J 47	4 55 14	0 24	303.5	2.73	9.4 – 9.6	23.07	J	2
				306.4	2.65	9.4 – 9.7	23.07	V	2
764	J 43	4 58 24	43 34	168.4	1.43	9.5 – 9.5	23.07	J	2
				165.9	1.84	9.4 – 9.4	23.07	V	2
776	J 320	5 1 8	10 36	123.8	3.47	9.9 – 9.9	17.53	J	2
	Nebula			247.0	183.62	Neb – 9.6	17.53	J	2
784	J 44	5 2 25	27 6	229.9	2.15	9.6 – 9.8	23.07	J	2
				228.4	2.04	9.7 – 10.0	23.07	V	2
823	Ait 2430	5 12 0	18 47	138.4	1.30	9.0 – 13.0	16.97	J	1
				127.2	1.43	9.4 – 12.8	22.12	J	1
				131.8	1.20	9.2 – 13.0	22.12	V	1
947	J 406	5 37 55	43 5	290.8	3.67	9.5 – 10.0	17.12	J	1
				293.8	4.43	9.6 – 10.9	22.13	J	2
				293.7	4.45	9.3 – 10.4	22.13	V	2
987	J 36	5 44 2	3 53	145.6	1.84	7.2 – 10.0	17.12	J	1
				143.3	1.72	7.5 – 9.4	22.11	J	2
				143.3	1.78	7.5 – 9.8	22.11	V	2
1055	J 407	5 55 55	9 41	192.8	2.24	8.5 – 9.8	22.12	J	3
				194.9	2.30	8.7 – 10.2	22.14	V	2

J.C.	Name	R.A.	Decl.	p	d	Mag	1900	Obs	n
		h m s	° ′	°	″				
1071	J 50	5 58 21	8 1	56.2	0.50	8.7 — 8.7	17.12	J	1
				63.9	0.62	8.7 — 8.7	22.11	J	2
				59.1	0.80	8.9 — 8.9	22.11	V	2
1084	J 335	5 59 42	11 2	297.0	0.57	7.5 — 9.1	17.15	J	1
				298.0	0.81	8.1 — 9.5	22.01	J	2
				295.0	0.89	7.9 — 9.5	22.01	V	2
. . .	J 1349	6 17 51	19 20	358.6	2.76	9.1 — 13.3	22.73	J	3
				357.8	3.45	9.5 — 13.0	21.97	V	1
1222	J 977	6 20 42	25 19	114.4	2.81	9.6 — 10.0	17.14	J	1
				116.3	3.25	9.6 — 10.6	22.08	J	2
				114.5	3.17	9.5 — 10.7	22.08	V	2
1245	J 660	6 24 26	4 52	97.9	2.23	9.3 — 9.3	22.64	J	2
				95.5	2.38	9.1 — 9.4	22.61	V	2
1357	J 267	6 40 21	8 14	86.9	1.65	9.2 — 9.2	22.62	J	2
				83.3	1.85	9.2 — 9.3	22.62	V	2
1447	J 278	6 54 18	6 17	147.2	2.28	9.0 — 9.2	18.08	J	1
				144.8	2.10	8.9 — 9.0	22.18	J	2
				142.6	2.28	9.0 — 9.3	22.18	V	2
1644	J 283	7 37 30	3 30	72.4	2.21	9.3 — 9.7	17.12	J	1
				70.1	2.21	9.2 — 9.3	22.21	J	2
				71.0	2.41	9.2 — 9.3	22.21	V	2
1826*	J 735	8 41 52	8 6	153.7	2.50	9.0 — 9.0	22.43	J	4
				152.6	2.49	9.0 — 9.1	22.43	V	1
. . .	J 1350	8 46 9	— 1 39	246.0	4.83	10.7 — 11.9	23.26	J	1
1838	J 74	8 46 10	1 43	105.1	1.08	9.6 — 9.7	22.92	J	3
				103.7	1.33	9.6 — 9.7	22.92	V	3
1839*	Van 3	8 46 21	8 9	91.5	2.22	8.8 — 9.0	22.13	J	4
				94.1	2.16	9.0 — 9.1	22.15	V	3
1844	J 75	8 49 1	1 55	32.6	3.10	8.9 — 11.9	22.25	J	2
				33.9	3.70	9.0 — 11.8	22.25	V	2
2046*	J 79	10 34 44	7 48	142.8	1.71	8.2 — 9.2	23.27	J	2
				141.7	1.79	8.3 — 9.3	23.27	V	2
. . .	J 1351	10 34 59	7 18	158.4	4.07	9.5 — 9.9	23.29	J	1
				157.0	4.25	9.5 — 9.9	23.29	V	1
2065	J 80	10 47 28	7 0	213.9	1.11	8.8 — 9.5	23.65	J	2
				216.7	3.74	9.1 — 9.8	23.65	V	2
2092*	J 81	11 3 49	10 38	132.5	1.70	9.2 — 9.2	23.65	J	2
				137.0	1.77	9.2 — 9.3	23.65	V	2
2095	J 82	11 5 50	11 20	112.5	1.57	9.4 — 9.5	23.65	J	2
				114.5	1.90	9.5 — 9.7	23.65	V	2
2121	J 86	11 30 15	4 34	95.8	2.14	8.9 — 9.8	23.65	J	2
				94.1	1.81	8.6 — 9.7	23.65	V	2
2384	J 444	15 37 41	— 0 33	319.7	3.04	9.0 — 9.8	20.54	J	2
				318.6	3.02	9.0 — 10.0	22.62	V	1
2490	J 450	17 14 0	7 37	65.7	2.96	9.9 — 10.6	20.54	J	2
				65.4	3.45	9.8 — 10.3	22.65	V	1
2491	J 451	17 15 6	4 16	251.0	3.51	9.4 — 12.1	20.54	J	2
				251.0	1.00	9.4 — 13.0	22.65	V	1
2496*	J 452	17 17 10	15 28	294.1	2.58	9.6 — 11.3	20.56	J	2
				294.6	2.75	9.5 — 11.0	22.68	V	1

J C	Name	R A	Decl.	p	d	Mags.	1900+	Obs.	n.
		h m s	° ′	°	″				
2540	J 516	17 11 19	− 0 31	242.3	2.93	9.0 − 9.4	14.47	J	2
				243.5	3.16	. . − . .	14.47	Cox	2
				238.8	3.27	9.2 − 9.7	22.63	J	2
				237.5	3.28	9.0 − 9.6	22.63	V	2
2545	J 456	17 13 1	− 1 29	96.8	2.63	9.7 − 9.7	14.46	D	1
				99.4	2.91	9.6 − 9.6	18.51	J	2
				102.2	2.88	9.6 − 9.6	22.62	V	1
2549	J 753	17 44 38	15 48	273.8	1.08	9.4 − 9.5	14.46	J	1
				271.0	1.18	9.4 − 9.4	14.46	D	1
				272.8	1.38	9.4 − 9.5	22.72	J	2
				273.5	1.51	9.6 − 9.7	22.72	V	2
2550	J 754	17 45 44	24 53	51.0	1.26	8.9 − 9.9	14.46	J	1
				49.6	1.33	8.9 − 9.4	14.46	D	1
				49.5	1.35	8.9 − 9.9	22.72	J	2
				49.8	1.52	9.0 − 9.6	22.72	V	2
2564	J 459	17 53 2	18 8	53.8	3.08	9.0 − 9.8	14.46	J	1
				56.4	3.23	9.3 − 9.8	14.46	D	1
				50.7	3.15	9.3 − 10.1	22.72	J	3
				50.4	3.05	9.4 − 10.1	22.73	V	2
	J 1352	17 53 12	18 13	23.8	3.97	10.0 − 11.0	22.68	J	1
				22.2	4.05	10.4 − 11.5	22.68	V	1
2566	J 517	17 53 37	0 15	288.0	3.74	9.0 − 11.0	17.47	J	1
				286.0	3.62	9.1 − 11.2	22.72	J	2
				286.4	3.58	9.1 − 11.7	22.72	V	2
2571	J 755	17 56 21	37 16	148.4	1.93	9.0 − 9.8	14.46	J	1
				146.0	1.90	9.1 − 9.8	14.46	D	1
				148.5	1.47	9.3 − 9.7	22.72	J	2
				148.1	1.65	9.1 − 9.8	22.72	V	2
2577	J 756	17 58 11	46 11	181.6	2.97	9.3 − 9.7	14.46	J	1
				181.4	3.33	9.4 − 9.8	14.46	D	1
				182.0	3.28	9.8 − 10.6	22.72	J	2
				181.6	2.80	9.5 − 10.0	22.72	V	2
2582	J 757	18 0 31	38 5	322.6	2.77	9.5 − 10.0	14.46	J	1
				323.0	3.13	9.4 − 10.0	14.46	D	1
				323.2	3.08	10.5 − 11.5	22.63	J	1
				320.8	3.25	9.7 − 10.8	22.63	V	1
2586	J 460	18 0 51	3 31	84.1	1.91	9.3 − 9.5	22.64	J	2
				86.5	2.01	9.5 − 9.5	22.64	V	2
2596	J 758	18 2 35	38 5	127.2	2.64	9.2 − 9.4	14.46	J	1
				126.8	2.55	9.2 − 9.4	14.46	D	1
				121.3	3.01	9.4 − 9.6	22.64	J	2
				120.9	2.97	9.5 − 9.7	22.64	V	2
2598	J 94	18 3 6	13 57	315.2	3.50	9.3 − 9.5	14.47	J	1
				314.6	3.00	−	14.47	Cox	1
				315.4	3.73	9.3 − 9.6	22.63	J	1
				311.2	3.65	9.6 − 9.6	22.63	V	1
2649	J 96	18 29 6	6 33	149.1	3.35	9.1 − 9.6	22.65	J	3
				146.0	3.27	9.2 − 9.8	22.65	V	3
	J 1353	19 5 19	64 51	348.0	3.82	9.7 − 9.9	22.38	J	1
				346.8	3.52	9.8 − 10.0	22.38	V	1

J.C.	Name	R.A.	Decl.	p	d	Mags.	1900+	Obs.	n.
		h m s	° ′	°	″				
2851	J 114	19 13 14	− 0 34	203.9	5.06	9.6 − 11.2	21.77	J	3
				205.6	5.22	9.6 − 11.1	21.77	V	3
2868	J 115	19 17 34	− 1 30	4.9	4.17	9.7 − 11.3	21.77	J	3
				0.0	3.91	9.7 − 11.4	21.77	V	3
	AC			41.1	8.48	9.7 − 12.6	21.77	J	3
				41.5	8.18	9.7 − 12.0	21.77	V	3
2869*	J 116	19 17 37	− 1 32	102.7	3.95	9.1 − 9.7	21.78	J	4
				100.9	4.07	9.5 − 9.7	21.77	V	3
2882	J 148	19 20 22	4 2	167.2	4.17	9.5 − 11.8	21.77	J	3
				165.1	4.19	9.6 − 12.0	21.77	V	3
2918	J 137	19 26 29	18 15	19.7	3.97	9.0 − 11.3	21.77	J	3
				17.3	4.33	9.2 − 10.9	21.77	V	3
2922	J 540	19 26 54	9 18	123.9	2.89	9.2 − 9.7	21.75	J	3
				121.6	3.12	9.3 − 9.7	21.75	V	3
2937	J 149	19 29 56	18 3	125.3	1.80	8.7 − 10.5	14.67	J	2
				123.7	2.25	8.8 − 10.9	21.82	J	3
				120.4	2.18	9.0 − 11.4	21.82	V	3
2954	J 24	19 32 27	20 38	258.5	2.85	9.2 − 10.2	21.77	J	3
				259.3	2.79	9.2 − 10.6	21.77	V	3
2959	J 171	19 33 6	9 0	251.7	3.63	9.8 − 10.0	21.77	J	3
				251.5	3.68	9.7 − 9.9	21.77	V	3
2969	J 120	19 34 13	− 1 28	96.0	2.03	9.0 − 9.6	21.75	J	3
				95.1	2.38	9.1 − 9.7	21.75	V	3
2985	J 1136	19 37 17	13 27	104.9	3.37	9.5 − 10.9	21.76	J	3
				101.9	3.48	9.4 − 10.6	21.78	V	2
3003	J 140	19 40 12	15 22	232.1	3.24	9.6 − 11.3	21.78	J	3
				229.6	3.17	9.5 − 11.8	21.78	V	3
3023*	J 150	19 42 48	10 12	198.2	1.68	9.5 − 9.7	21.75	J	3
				196.3	1.79	9.6 − 9.7	21.75	V	3
3042	J 152	19 46 9	7 29	167.9	2.94	9.2 − 10.7	21.77	J	3
				165.6	2.97	9.2 − 11.3	21.77	V	3
3045	J 141	19 46 57	17 14	42.8	4.15	9.3 − 9.4	21.75	J	3
				43.7	3.97	9.4 − 9.7	21.75	V	3
	J 1354	19 47 23	64 22	193.6	3.83	9.6 − 11.5	22.39	J	1
				191.8	3.37	9.8 − 12.0	22.39	V	1
3054	J 125	19 48 16	41 28	217.5	1.95	8.9 − 9.3	21.77	J	3
				213.5	2.01	9.0 − 9.5	21.77	V	3
3059	J 172	19 48 30	9 21	287.8	4.84	9.6 − 13.1	21.78	J	3
				288.2	4.77	9.5 − 12.9	21.78	V	3
3062	J 151	19 49 3	18 37	195.8	3.94	9.9 − 12.0	21.84	J	4
				193.4	3.94	9.6 − 11.9	21.84	V	4
3068	J 25	19 50 9	29 10	3.9	1.24	9.5 − 9.5	21.75	J	3
				1.3	1.36	9.5 − 9.5	21.75	V	3
3085	J 153	19 52 23	11 38	1.4	1.21	9.6 − 9.7	21.82	J	3
				2.3	1.46	9.5 − 9.5	21.82	V	3
3101	J 818	19 54 37	8 39	20.6	0.93	9.8 − 9.8	21.76	J	3
				19.1	1.11	9.8 − 9.8	21.76	V	3
	AB-C			186.6	23.75	9.5 − 9.6	21.76	J	3
				186.6	23.50	9.6 − 9.7	21.76	V	3

J.C	Name	R.A.	Decl.	p	d	Mags.	1900+	Obs.	n.
		h m s	° ′	°	″				
3129	J 173	19 57 27	9 37	51.3	7.29	9.5 – 13.4	21.86	J	3
				52.3	7.88	9.5 – 13.3	21.86	V	3
3130	J 154	19 57 35	– 4 8	55.4	4.06	9.9 – 10.3	21.89	J	3
				57.3	4.01	9.8 – 10.3	21.89	V	3
3139	J 174	19 58 56	9 48	172.0	4.37	9.5 – 12.5	21.89	J	3
				170.5	4.36	9.5 – 12.4	21.89	V	3
3153	J 603	20 1 44	4 20	128.6	3.10	9.3 – 9.3	14.49	J	1
				128.1	2.75	9.4 – 9.5	21.74	J	3
				127.8	2.90	9.5 – 9.6	21.74	V	3
3154	J 546	20 1 52	7 31	291.6	2.45	9.4 – 9.6	21.74	J	3
				291.0	2.59	9.5 – 9.7	21.74	V	3
3156	J 134	20 2 8	10 21	91.6	6.48	9.3 – 11.3	21.85	J	3
				92.9	6.18	9.3 – 10.7	21.86	V	4
3182	J 136	20 7 56	11 1	261.1	1.50	9.4 – 9.8	21.74	J	3
				262.5	1.80	9.5 – 9.8	21.74	V	3
3186	J 127	20 8 59	34 55	1.9	3.69	9.8 – 10.0	21.85	J	3
				3.2	4.28	9.6 – 9.7	21.85	V	3
3188	J 176	20 9 9	10 14	295.0	1.54	9.3 – 12.4	17.30	J	2
3211	J 135	20 11 54	9 47	319.7	3.26	9.7 – 10.0	21.85	J	3
				321.2	3.56	10.0 – 10.2	21.85	V	3
3265	J 129	20 20 57	38 59	33.3	3.84	9.3 – 9.6	21.86	J	3
				33.6	3.89	9.3 – 9.5	21.86	V	3
3278	J 559	20 23 16	9 32	213.0	3.05	9.3 – 9.3	14.63	J	1
				220.3	2.91	9.8 – 9.8	22.73	J	2
				217.1	2.76	9.7 – 9.7	22.73	V	2
3296	J 130	20 27 9	41 31	261.5	2.62	9.2 – 9.5	21.86	J	3
				264.9	2.80	9.3 – 9.5	21.86	V	3
3307	J 3	20 27 46	11 34	130.2	1.16	10.0 – 10.2	21.85	J	3
				130.5	1.39	9.9 – 10.1	21.85	V	3
3317	J 4	20 29 5	14 28	43.8	1.04	9.1 – 9.4	21.85	J	3
				38.8	1.21	9.2 – 9.6	21.85	V	3
3323	J 190	20 30 33	32 55	330.7	2.48	9.1 – 12.3	21.89	J	3
				332.8	2.44	9.2 – 11.8	21.89	V	3
	AC			105.1	6.24	9.1 – 13.9	21.89	J	3
				104.3	6.69	9.2 – 13.5	21.89	V	3
3326	J 4	20 30 50	47 35	356.1	2.30	9.5 – 9.8	21.86	J	3
				356.5	2.58	9.4 – 9.6	21.86	V	3
3357	J 156	20 36 20	3 32	21.7	2.00	9.4 – 9.6	21.90	J	2
				20.3	2.03	9.5 – 9.6	21.90	V	2
3362	J 191	20 37 13	17 21	61.1	3.35	9.5 – 9.9	21.94	J	2
				61.4	3.51	9.5 – 9.8	21.94	V	2
3445	J 157	20 51 56	8 16	170.8	3.93	9.3 – 9.3	14.73	J	1
				170.6	3.87	9.3 – 9.3	22.65	J	1
				171.4	4.00	9.4 – 9.4	22.65	V	1
	J 1355	20 52 5	8 17	327.6	2.04	10.8 – 10.8	22.65	J	1
				326.4	1.90	10.5 – 10.5	22.65	V	1
3484	J 576	21 8 28	7 25	233.4	2.05	9.3 – 9.3	14.72	J	1
				232.6	2.25	9.4 – 9.4	22.73	J	2
				231.1	2.24	9.5 – 9.5	22.73	V	2

J.C.	Name	R.A.	Decl.	p	d	Mags.	1900+	Obs.	n.
		h m s	° ′	°	″				
. .	J 1356	21 18 31	9 32	174.0	1.80	9.6 – 10.0	14.73	J	1
				177.0	1.95	9.7 – 10.8	21.97	J	1
				175.2	5.10	9.6 – 11.0	21.97	V	1
3514	J 161	21 18 35	10 37	122.7	1.48	9.0 – 9.0	21.88	J	3
				120.0	1.66	9.2 – 9.1	21.93	V	2
3534	J 197	21 25 26	14 30	23.9	3.11	9.1 – 9.4	21.93	J	2
				21.3	3.00	9.3 – 9.3	21.93	V	2
3539	J 199	21 26 58	8 7	186.1	4.09	9.6 – 9.8	23.41	J	2
				186.5	4.11	9.8 – 10.0	23.41	V	2
3540	J 178	21 27 2	11 20	188.3	2.68	9.5 – 9.6	23.41	J	2
				188.1	2.54	9.6 – 9.8	23.41	V	2
3552	J 200	21 30 36	14 54	313.3	2.42	9.3 – 9.4	21.90	J	3
				313.5	2.63	9.4 – 9.4	21.90	V	3
3561	J 163	21 32 23	0 9	306.9	4.23	9.0 – 10.0	21.74	J	3
				305.9	4.20	9.1 – 9.8	21.74	V	3
3591	J 164	21 41 54	13 57	298.1	3.75	9.4 – 11.1	21.97	J	2
				297.5	4.31	9.5 – 11.7	21.97	V	2
3595	J 202	21 42 54	7 0	184.7	3.66	9.2 – 9.5	21.74	J	3
				182.1	3.50	9.2 – 9.6	21.74	V	3
3614	J 2	21 51 18	18 46	33.2	3.19	9.4 – 9.4	22.46	J	4
				32.0	3.12	9.5 – 9.6	22.46	V	4
3680	J 179	22 15 21	7 36	311.9	3.16	9.3 – 9.6	21.74	J	3
				310.1	3.51	9.3 – 10.5	21.74	V	3
3711	J 580	22 23 57	10 0	111.6	3.72	9.3 – 9.8	21.74	J	3
				111.2	3.92	9.4 – 9.9	21.74	V	3
3713	J 180	22 24 11	8 46	283.6	4.78	9.4 – 11.9	22.96	J	2
				288.9	5.15	9.1 – 11.5	21.90	V	1
3753	J 165	22 33 56	11 6	137.8	1.69	9.4 – 9.5	21.74	J	3
				131.7	2.09	9.3 – 9.4	21.74	V	3
3763	J 181	22 38 15	10 51	241.4	4.13	9.2 – 11.2	22.96	J	2
				244.7	4.70	9.3 – 11.0	22.96	V	2
. .	J 1357	22 43 27	24 40	70.8	1.36	9.5 – 9.6	21.64	J	3
	(BD+24°4659)			69.6	1.72	9.4 – 9.6	22.00	V	2
3786*	J 668	22 49 14	7 57	317.0	1.72	9.3 – 9.9	21.74	J	3
				315.2	1.98	9.3 – 9.9	21.74	V	3
3789*	Van 2	22 50 25	7 58	132.6	3.23	9.3 – 9.3	21.74	J	3
				130.5	3.28	9.3 – 9.3	21.74	V	3
				135.4	3.67	9.4 – 9.4	23.94	J	2
				132.2	3.45	9.3 – 9.3	23.94	V	2
3825	J 670	23 8 0	8 26	193.4	1.85	9.2 – 10.2	21.82	J	2
				191.9	1.60	9.4 – 10.2	21.82	V	2
				196.5	1.71	9.2 – 10.1	23.02	J	2
				195.8	1.48	9.3 – 10.2	23.02	V	2
3871	J 166	23 24 16	16 35	350.2	3.74	9.4 – 11.2	21.94	J	3
				349.8	4.07	9.1 – 10.9	21.94	V	3
3903	J 167	23 38 14	1 16	10.8	4.70	9.5 – 9.5	22.35	J	2
				8.7	4.97	9.6 – 9.6	22.35	V	2
. . .	J 1358	23 52 21	44 12	358.0	2.29	9.9 – 9.9	16.88	J	1
				1.7	2.47	9.7 – 9.9	21.98	J	2
				0.1	2.29	10.0 – 10.0	21.98	V	2

NOTES

22 Angle decreasing.
210 Angle decreasing.
733 Angle decreasing.
752 Angle decreasing.
1826 Angle decreasing.
1839 Angle increasing.
2046 This is BD $+8^\circ 2387$ not $+8^\circ 2389$.
2092 Angle decreasing.
2196 Distance increasing.
2869 Angle increasing.
3023 Angle increasing.
3786 Angle decreasing.
3789 Angle increasing.

Lille Observatory,
January 14, 1924.

PROPER-MOTIONS OF CERTAIN LONG-PERIOD VARIABLES,

BY ANNE S. YOUNG AND ALICE H. FARNSWORTH.

Proper-motions for the long-period variables of the following list were determined from measures of photographs taken with the 24-inch reflector of the Yerkes Observatory. The material given here corresponds to that of previous lists published in Nos. 784 and 791 of this *Journal*. The method of measurement and reduction followed is described in No. 784. Most of the later plates used for this series were taken by MISS FARNSWORTH during the summer of 1922.

Proper-motion was detected by the stereocomparator for only one star in 15 fields, and the date for this is given at the end of the list of variables. It is a faint star at the same declination as *θ Cygni* (magnitude 4.6), which it precedes by only 12ˢ. Its proper-motion is similar to that of the brighter star, given in Boss' *Preliminary General Catalogue*, as No. 5014, $\mu_\alpha = -^s.0029$, $\mu_\delta = +''.247$.

Star	R. A. (1900)	Decl. (1900)	Ep.	Int.	No. Stars	μ_α	μ_δ	Resid. in α	Resid. in δ
	h m s	° ′ ″		y		″ s	″		
U Arietis	3 5 30.09	+14 25 14.8	05.10	15.01	17	−.008 .0006	−.012	8	1
RR Librae	15 50 38.90	−18 0 39.9	09.54	10.00	16	−.007 .0005	−.010	15	2
R Ophiuchi	17 2 1.31	−15 57 34.0	08.48	14.14	15	+.006 .0004	−.019	6	0
T Sagittarii	19 10 28.08	−17 8 46.8	07.50	15.04	20	−.008 .0006	+.010	2	4
R Cygni	19 34 8.12	+49 58 29.6	07.45	15.08	23	+.020 .0021	+.009	2	2
W Aquarii	20 41 10.21	−4 26 54.1	07.77	14.85	18	−.044 .0030	+.018	1	2
U Capricorni	20 42 31.14	−15 9 5.4	07.70	14.93	21	+.020 .0014	+.044	2	1
RZ Cygni	20 48 32.16	+46 58 43.3	07.62	14.96	22	−.012 .0012	+.035	16	9
X Capricorni	21 2 49.20	−21 45 0.8	07.75	14.90	17	+.027 .0019	+.016	4	3
Z Capricorni	21 5 3.24	−16 31 48.7	07.60	15.05	9	−.032 .0022	−.012	14	6
RT Aquarii	22 17 42.00	−22 33 31.4	07.68	14.97	13	+.050 .0036	+.049	9	8
Y Cassiopeiae	23 58 13.57	+55 7 26.3	07.78	14.80	20	−.011 .0012	+.001	8	8
Anon, Mag. 13.5	19 33 33.6	+49 59 20	07.45	15.08	14	±.000 .0000	+.274	1	1

Mt. Holyoke College, South Hadley, Mass.,
May, 1924.

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ON PERIODIC CHANGES IN THE POSITION OF *POLARIS*,

By B. GERASIMOVIC.

In his well-known investigations of yearly refraction L. COURVOISIER found that the mean place of *Polaris* undergoes periodic oscillations corresponding to the motion of the bright star around the centre of gravity of the system, as indicated by the spectrographic observations. He later[1] determined the period of this oscillation to be 10 years, which is in fair agreement with the first oscillation period of γ, *i. e.*, of the velocity of the system, announced by CAMPBELL[2] in 1910. This result is important, not only as a piece of astrometric work, but it has considerable theoretical interest. *Polaris* is a *Cepheid*, or more properly, a so-called *pseudo-Cepheid*. The discovered oscillation, if established, would prove that this star is really a binary with a long period and thus lead us to suppose that many variables of similar type with analogous oscillations of γ are also binaries, a conclusion of great importance in the study of those variables.

It seems to me that there are several reasons for viewing COURVOISIER's results with a certain amount of skepticism, the chief of them being a new and more precise curve of the oscillation of γ derived by MISS LEHMANN[3] on the basis of spectrograms taken by A. BELOPOLSKY at Pulkovo. The new curve shows a definitely shorter period for γ, 8.5 years, which can not be reconciled with the oscillations of the mean place determined by COURVOISIER. This led me to undertake a more detailed investigation of the Pulkovo absolute positions of *Polaris* which formed the basis of COURVOISIER's research, as it seemed impossible to give only a summing up of the observations in an average. For the right-ascensions I used the series of observations in the catalogues of 1865 and 1885, and for the declinations those in the catalogues of 1865.

[1] *Astronomische Nachrichten* **203**, 85, 1916.
[2] *"Stellar Motions"* p. 253.
[3] *Pulkovo Mitteilungen* **6**, No. 5, 1914.

1. PULKOVO RIGHT-ASCENSIONS, CATALOGUE OF 1865.

An excellent series of observations of right-ascensions was made by WAGNER between 1860 and 1872, both by Eye and Ear, (O), and by Chronograph, (R). I investigated the differences $\Delta\alpha = \alpha - \alpha_0$, where α represents the mean place corresponding to the observation and α_0, the mean place of the catalogue. This investigation disclosed in the $\Delta\alpha$'s large deviations from the average in greater numbers than would be expected according to the error-law. From the 829 observations, 15 were excluded on the basis of PIERCE's criterion used with the greatest precision. The systematic difference O−R, (Eye and Ear-Chronograph) was derived from 268 differences in α, obtained simultaneously, with the following result:

$$O - R = -0^s.412 \pm 0^s.029,$$

which is in fair agreement with the extrapolated systematic difference from the value ($O - R = -0^s.57$) derived in the catalogue from the more southerly stars. Thereafter all the $\Delta\alpha$'s were reduced to $\frac{1}{2}(O+R)$.

A comparison of the observations of two culminations made on the same day gives for the average of 103 differences:

$$U - L = +0^s.055 \pm 0^s.087$$

This difference has been neglected. All the observations were then reduced for aberration using the International aberration constant and were corrected for parallax. The adoption of the most probable trigonometric parallax $0''.05$, did not eliminate the considerable monthly residuals in $\Delta\alpha$, indicating the necessity of determining π from the observations themselves. I made use of the value derived by

L. de Ball from these observations, $\pi = 0''.015$, which completely eliminated the monthly residuals.

These investigations resulted in a homogeneous system of $\Delta\alpha$'s. In view of the comparatively long period of the oscillations of γ, the $\Delta\alpha$'s have been combined into means covering two to five months. This process did not give absolutely equal-weighted means but the possible changes in the combinations would have little effect on the results.

Epoch	$\Delta\alpha$	Epoch	$\Delta\alpha$
1861.0	+0.07	1866.4	+0.02
1861.4	+0.16	1867.7	−0.01
1862.0	+0.11	1868.6	−0.30
1862.4	+0.05	1869.0	−0.10
1862.7	−0.21	1869.5	−0.25
1863.5	−0.21	1870.0	−0.09
1863.8	−0.06	1870.5	−0.11
1864.3	−0.09	1870.9	−0.01
1864.8	+0.01	1871.5	−0.02
1865.5	−0.02	1872.3	+0.10
1865.9	+0.05	1872.7	+0.06

We see clearly that the $\Delta\alpha$'s do not reveal periods of either ten or eight years. The observations of 1860–65, all of which were arbitrarily rejected by Courvoisier, give a maximum of $\Delta\alpha$ in 1861, which does not correspond in any way with the orbit. Other maxima occur in 1866 and 1872, when Courvoisier's orbit gives $\Delta\alpha = 0$. But the changes in $\Delta\alpha$ do show a certain periodicity. The maxima in 1861.5, 66.0 and 72.5 and the minima in 1863.2 and 68.5 give a mean period of about 5.1 years. The amplitude of this apparent oscillation is 0.11. To what extent it represents a real change in the position of *Polaris* remains an open question.

II. Pulkovo Right-Ascensions, Catalogue of 1885[1]

These observations were made between 1880 and 1887 by Wagner, Wittram and Harzer. Thirteen observations were excluded on the basis of Pierce's criterion. Personal differences between the three observers were determined from comparisons of monthly averages. The differences Wg–Wit, appeared negligible, but the following differences, Wg – Hrz, were obtained

Method (O), +0.35 ± 0.18;
Method (R), +0.52 ± 0.21.

The calculations for this part of the discussion were made by Miss R. Zaltowa, research-fellow in Astronomy at Kharkow.

[1] *Astronomische Nachrichten* **112**, 11, 1885.

With these differences the observations were reduced to Wg. The comparison (O–R) gave −0.35 ± 0.11, in good agreement with that derived from the Catalogue of 1865. The observations were reduced to $\frac{1}{2}$(O + R). The comparison of the two culminations gave

U – L = +0.11 ± 0.15, which was neglected.

All the observations were then reduced to the international aberration and corrected for a parallax, $\pi = 0''.05$. The averages then obtained revealed monthly residuals, susceptible to a correction of the form:

$$\text{Corr.} = -0.08 + 0.11 \sin (wt + 68^\circ)$$

This shows that a parallax nearer zero, such as de Ball's value, will better satisfy the observations. Mean values of $\Delta\alpha$ were derived as follows:

Epoch	$\Delta\alpha$	Epoch	$\Delta\alpha$
1881.0	−0.10	1884.7	−0.30
1881.8	−0.16	1885.3	−0.17
1882.4	+0.02	1885.6	−0.33
1883.0	+0.02	1886.0	−0.18
1883.7	−0.01	1886.5	−0.27
1884.3	−0.11	1887.0	−0.20
		1887.6	−0.38

The observations reveal a trend in mean $\Delta\alpha$ proportional to the time t, which corresponds to an annual change of place, corrected for the adopted proper-motion, of 0.03. The corrected $\Delta\alpha$'s show two maxima, in 1882.7 and 1885.2. There is no evidence of Courvoiser's period or of the five-year period. The trend of the $\Delta\alpha$'s does not correspond in any way to Courvoiser's orbit. The maxima in 1861.5 and 1882.6 may be represented by a period of 5.3 years, but I am convinced that this period is illusory. Even if the trend in the $\Delta\alpha$'s in 1860–70 is real, I do not believe that it represents the true motion of *Polaris*.

III. Pulkovo Declinations, Catalogue of 1865.

The observations were made by Gyldén from 1863–71 and by Nyrén from 1871–75, with no overlapping of observers. The application of Pierce's criterion revealed 29 observations subject to exclusion but, as they were distributed systematically in time, no exclusions were made. As before the observations were corrected for the international aberration and

for parallax, using DE BALL's value. The observations were then combined according to culminations and the mean $\Delta\delta$'s derived. As the different culminations entered with unequal weights in the separate groups, the $\Delta\delta$'s were corrected for latitude-variation, using IWANOW's latitude variations determined from all the stars of this catalogue. The corrected $\Delta\delta$'s gave the following mean values:

Epoch	$\Delta\delta$	Epoch	$\Delta\delta$
1864.1	+0″.11	1870.2	(−0 .10)
1864.7	+0 .10	1871.7	−0 .01
1865.5	+0 .07	1872.4	−0 .01
1866.9	+0 .11	1872.8	−0 .01
1867.5	+0 .06	1873.3	−0 .02
1868.7	+0 .07	1874.5	−0 .10
1869.6	+0 .03	1875.2	−0 .13

Evidently neither ten nor five year periods are revealed by $\Delta\delta$. The $\Delta\delta$'s observed by GYLDEN are practically constant with an average of +0″.08. NYREN's $\Delta\delta$'s are, likewise, practically constant with an average of −0″.05. The sharp change in $\Delta\delta$ with the beginning of NYREN's observations may, therefore, be ascribed to the personal difference, GYLDEN − NYREN = +0″.13.

A detailed analysis of the Pulkovo observations of *Polaris* does not, therefore, reveal in them any trace of the period discovered by COURVOISIER. When I had nearly completed the calculations described above, PROF. A. BELOPOLSKY kindly sent me his unpublished spectrographic observations of *Polaris*. The new observations and the new reductions of the earlier Pulkovo observations show that from 1906 to the present the velocity of the system, γ, has been practically constant, changing only from −17.8 km. to −16.5 km. This agrees with the results of the *Lick* observers who found $\gamma = -15.8$ km. in 1910 and $\gamma = -17.8$ in 1916. The period of variation of γ must, therefore, be in the neighborhood of 30 years.

There is, therefore, little reason for believing that *Polaris* has a long-period satellite which disturbs its motion. The well-known 9th magnitude companion is only optical. COURVOISIER considers it a physical satellite of the bright star with a period about 50,000 years but, as he himself has shown, the distance change in 100 years is zero and the change in position angle is less than the probable error. *Polaris* may be either a double star with a period of four days or, according to the pulsation hypothesis, a single gaseous sphere with a pulsation period of four days. In its effect upon the theory of *Cepheid* variation, this negative result in the search for a longer-period variation in the position of *Polaris* is important.

Astronomical Observatory, Kharkoff, Russia,
December, 1925.

ON THE DISTANCE OF THE LARGE MAGELLANIC CLOUD.

BY RALPH E. WILSON.

In *Harvard College Observatory Bulletin* No. 801, April 1, 1924, MISS CANNON gives the photographic magnitudes of 32 stars of Class O in the Large Magellanic Cloud. As there can be no question but that these stars are actually within the Cloud, they must all be at the same order of distance from us and their apparent magnitudes may, therefore, be taken as measures of their absolute magnitudes. While we have no means of getting an accurate color-correction to reduce the photographic magnitudes to visual, an approximation may be made by using the color-correction for the Class-B stars, $-0^m.2$ The total range in magnitude of the Magellanic stars is about five magnitudes.

In an unpublished investigation of the motions and mean luminosities of the galactic Class-O stars we find a range in the mean absolute magnitudes of some four magnitudes. If we may assume that the stars of this type have similar luminosities regardless of their situation, we may use them to get an estimate of the distance of the Large Magellanic Cloud. For instance, we find that the brightest galactic Class-O stars have a mean absolute magnitude, $M = -5.8$, the faintest give, $M = -1.5$, while the median value from 84 stars is about, $M = -3.4$. The three brightest Magellanic Class-O stars have a mean visual magnitude, $m = 10.2$; for the three faintest, $m = 14.3$; while the mean value is, $m = 12.5$. If we assume that the latter have the absolute magnitudes defined by the corresponding groups of gallactic stars, we get the following estimates of the parallax of the Cloud:

	π
Bright stars	″.000056
Faint stars	.000063
Mean magnitudes	.000079
Mean	″.000066

It is a coincidence that this value of the parallax is almost the mean between the estimate by HERTZSPRUNG, ″.0001[2], and the value derived by SHAPLEY[3] from the apparent diameters of five clusters within

the Cloud, ″.000029. The distance corresponding to this value of the parallax is 15000 parsecs, or 50000 light years. It is of interest to note that this distance is about the same as the mean of the estimates of HERTZSPRUNG[1] and SHAPLEY[2] for the distance of the Small Magellanic Cloud, 10000 and 19000 parsecs respectively, and quite in harmony with HERTZSPRUNG's suggestion[3] that the two clouds are moving together in space.

[1] *Astronomische Nachrichten* **196**, 204, 1914.
[2] *Monthly Notices* **80**, 782, 1920.
[3] *The Observatory* **46**, 58, 1923.

Dudley Observatory, Albany, N. Y., May 29, 1924.

ELEMENTS AND EPHEMERIS OF 1923 IF 21,

BY ERNEST CLARE BOWER AND JOHN EDWIN WILLIS.

[Communicated by CAPTAIN E. T. POLLOCK, U. S. Navy, Superintendent of U. S. Naval Observatory.]

1923 IF 21 was discovered 1923 May 21 by G. H. PETERS at Washington, estimated magnitude 12.5. Observations by him with the 10-inch triplet are as follows:

	G. C. T.	Astrografic 1900.0 α	Astrografic 1900.0 δ	ΔX (unit = 0000.001)	ΔY	From Orbit I Δα	From Orbit I Δδ	From Orbit II Δα	From Orbit II Δδ	From Orbit III Δα	From Orbit III Δδ
		° ′ ″	° ′ ″			″	″	″	″	″	″
(1)	1923 May 21.49097	244 28 30.9	+0 51 29.0	+203	+263	+10.4	−1.4	+0.1	−1.0	−0.4	−1.0
(2)	25.20439	244 12 11.1	+0 49 51.1	+180	+279	+ 9.9	−3.0	+0.3	−0.1	−0.1	−0.0
(3)	26.22361	243 55 12.6	+0 48 0.0	+131	+301	+10.3	−2.2	+1.5	+0.1	+1.2	+0.5
(4)	June 2.17014	242 2 46.2	+0 30 43.3	+196	+268	.	..	+1.0	+0.8	+1.0	+1.3
(5)	5.16597	241 11 26.1	+0 19 45.4	+190	+273	.	..	−3.5	+0.1	−2.6	+0.8
(6)	10.15117	239 56 9.9	−0 1 20.7	+186	+275	0.0	0.0	0.0	0.0	0.0	0.0
(7)	18.15903	237 59 29.4	−0 11 20.2	+138	+303	.		−0.8	+3.2	−0.9	+1.9
(8)	19.13611	237 16 17.4	−0 50 20.7	+175	+283	.	.	−0.1	+1.8	−0.6	+0.3
(9)	July 1.09583	235 27 36.6	−2 44 16.8	+188	+274	+ 5.5	−6.1	−0.5	+0.0	−0.0	−4.8
				ΔZ = −267							

Orbit I, a direct solution by LEUSCHNER's method, *Lick Pub.* **7**, was based on (1), (2) and (3) as a normal first, (6) as middle, and (9) as third place. α′, α″, δ′, δ″, were derived from (1), (4), (6), (8) and (9). The residuals are tabulated above.

A single correction, giving Orbit II and the following elements, yielded the residuals tabulated above.

ELEMENTS AND CONSTANTS FOR EQUATOR

Epoch 1923 June 10.14297 G.C.T.

M	239°.09473		
μ	0°.2678564	m_0 =	11.4
a	2.383125	g =	8.8
e	0.301105		
i	24° 13′ 38″.6	1900.0	
☊	96 59 32 .4	1900.0	
ω	290 31 10 .2	1900.0	

$$\left.\begin{array}{l} x = .913294\, r \sin(148^\circ\ 10'\ 45''.9 + v) \\ y = .948394\, r \sin(\ 36\ \ 15\ \ 18\ .6 + v) \\ z = .516192\, r \sin(340\ \ 27\ \ \ 4\ .4 + v) \end{array}\right\}\ 1900.0$$

This asteroid does not seem to be identical with any for which an orbit has been published. It has been named *Potomac*.

The parallax was treated as in *A. J.* **28**, 108 and as suggested in *A. J.* **31**, 29. This method is simplest when, as usual, the residuals are formed directly and not by comparison with an ephemeris.

1924 25 EPHEMERIS

G.C.T.	α_{1900}		δ_{1900}		(r) ρ	m
	h m		° ′			
1924 July 13	2 54.0		− 8 51		(1.709)	11.1
		24.6		45		
23	3 18.6		8 6		1.619	11.0
		23.7		35		
Aug. 2	3 42.3		7 31		1.547	10.9
		22.7		26		
12	4 5.0		7 5		1.478	10.8
		21.3		17		
22	4 26.3		6 48		1.409	10.7
		19.8		9		
Sept. 1	4 46.1		6 39		1.342	10.6
		17.8		3		
11	5 3.9		6 36		1.274	10.5
		15.5		1		
21	5 19.4		6 35		1.206	10.3
		12.7		4		
Oct. 1	5 32.1		6 31		1.138	10.2
		9.6		10		
11	5 41.7		6 21		1.071	10.1
		5.7		24		
21	5 47.4		5 57		(1.704)	10.0
		1.3		47		

G.C.T.			α_{1900}		δ_{1900}		(r)	m
			h m		° ′		ρ	
1924	Oct.	31	5 48.7	3.2	+5 10	80	0.947	9.9
	Nov.	10	5 45.5	7.8	3 50	123	0.896	9.7
		20	5 37.7	11.2	+ 1 47	166	0.859	9.7
		30	5 26.5	13.4	− 0 59	207	0.840	9.7
	Dec.	10	5 13.1	13.3	4 26	227	0.844	9.7
		20	4 59.8	10.9	8 13	230	0.875	9.8
		30	4 48.9	7.3	12 3	218	0.932	10.0
1925	Jan.	9	4 41.6	2.9	15 41	195	1.013	10.2
		19	4 38.7	1.3	18 56	170	1.115	10.5
		29	4 40.0	5.2	21 46	147	(1.955)	10.7
	Feb.	8	4 45.2	8.5	24 13	125	1.361	11.0
		18	4 53.7	11.3	26 18	106	1.504	11.2
		28	5 5.0	13.5	28 4	89	1.650	11.4
	Mar.	10	5 18.5	15.4	29 33	73	1.800	11.6
		20	5 33.9	16.9	30 46	57	1.952	11.8
		30	5 50.8	18.0	31 43	43	2.104	12.0
	Apr.	9	6 8.8	19.0	32 26	30	2.254	12.2
		19	6 27.8	19.5	32 56	17	2.404	12.4
		29	6 47.3	20.1	33 13	4	2.544	12.6
	May	9	7 7.4		+33 17		(2.301)	12.8

At opposition a correction to the ephemeris of $+1^m$ in α corresponds to $+8'.3$ in δ.

Addendum

Identity with (323) *Brucia* is unlikely. Observations of the latter are represented as follows:

Reference	Date	From Orbit II $\Delta\alpha$	From Orbit II $\Delta\delta$	From Orbit III $\Delta\alpha$	From Orbit III $\Delta\delta$
		m	° ′	′ ″	′ ″
AN **139**, 101	1891 Dec. 22	−19.1	−1 56	+25 46.0	−15 26.4
101	23	−19.6	−1 56	+25 53.1	−15 43.5
129, 15	31	−19.8	−1 55	+26 16.5	−15 43.6
31	1892 Jan. 1	−19.9	−1 54	+26 23.5	−15 44.4

Keeping the other elements of Orbit II unchanged, $\mu = 0''.2680097$ was found to give residuals for 1891 Dec 31 of $\Delta\alpha = 0^m.0$, $\Delta\delta = -23'$. Introducing the corresponding $\frac{1}{a}$ in the correction gave Orbit III, which represented all observations as tabulated.

By correcting the data of Orbit III, an orbit with 1892, Jan. 1 as first, (1) as middle, and (9) as third place, gave these residuals:

	1891 Dec. 22	1891 Dec. 23	1892 Jan. 1	(1)	(5)	(6)	(9)
	″	″	″	″	″	″	″
$\Delta\alpha$	+ 56.6	+ 52.4	−1.2	0.0	+ 0.7	+ 6.6	+0.1
$\Delta\delta$	−314.5	296.4	−1.5	0.0	−12.2	−14.5	0.0

Altho perturbations are neglected, the run of these residuals and a discrepancy of 1.4 magnitudes seem to disprove identity.

The above is volunteer work.

U. S. Naval Observatory, Washington, D. C., 1924 March 19.

OBSERVATIONS DE PLANÈTES ET DE COMÈTE,

FAITES À L'OBSERVATOIRE DE BESANÇON, ÉQUATORIAL COUDÉ DE 0^m 33 d'ouverture,

PAR M. P. CHOFARDET.

Dates	T. m. Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log. f.p.	Réd. au j.		★
					(10) *Hygiea*						
1923	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Oct. 30	7 4 29	+2 29.93	− 8 30.1	9,12	22 13 12.28	8.840n	96 36 27.1	0.851n	+2.58	−20.3	1
31	6 43 18	+2 39.50	− 8 30.4	9,12	22 13 21.83	8.974n	96 36 27.2	0.851n	+2.56	−20.2	1
					(11) *Parthenope*						
Avril 9	12 26 40	+0 47.53	− 3 6.3	9, 6	15 54 58.39	9.372n	103 10 9.3	0.870n	+1.73	− 0.6	2
Mai 4	11 41 32	+0 5.69	− 3 6.6	9, 6	15 40 0.99	9.163n	101 16 2.3	0.875n	+2.19	+ 0.5	3
5	10 33 26	−0 14.19	− 6 24.7	9, 6	15 39 11.12	9.357n	101 12 14.2	0.867n	+2.26	+ 0.5	3
					(16) *Psyche*						
Juin 7	10 59 0	−0 3.97	− 7 30.9	9, 8	14 25 21.78	9.214	100 5 59.5	0.865n	+2.24	+ 4.1	4
8	11 11 2	−0 30.16	− 8 56.5	9, 8	14 24 55.59	9.276	100 4 33.6	0.863n	+2.21	+ 1.0	4
9	11 5 10	−0 54.78	−10 13.2	9, 8	14 24 30.97	9.275	100 3 16.9	0.863n	+2.21	+ 4.6	4

Date	T. m. Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log f.p.	Réd. au j.		★
					(21) *Lutetia*						
d	h m s	m s	"		h m s		° ' "		s	"	
Avril 9	11 3 10	1 36.27	+ 7 20.1	9, 8	13 28 10.16	9.119n	91 11 11.3	0.816n	+1.90	+ 7.8	5
10	11 35 50	2 33.51	+ 2 3.9	9,12	13 27 13.20	8.835n	91 35 58.1	0.810n	+1.91	+ 7.8	5
Mai 1	10 17 58	0 18.75	2 17.7	6, 6	13 6 28.19	8.697	92 50 10.9	0.829n	+1.92	+ 8.1	6
5	9 16 1	1 0.76	− 5 11.1	9, 6	13 5 16.17	8.701n	92 47 17.2	0.829n	+1.91	+ 8.1	6
					(43) *Ariadne*						
Oct. 31	7 7 33	+0 58.22	−10 23.1	9, 6	23 0 12.95	9.148n	90 39 31.2	0.815n	+2.81	−21.6	7
Nov. 5	7 50 10	2 4.65	+ 2 2.2	6, 8	23 1 17.02	8.122n	90 11 26.7	0.816n	+2.77	−21.2	8
8	6 37 1	0 19.50	+ 2 35.1	9, 8	23 3 2.11	9.125n	90 15 0.0	0.816n	+2.74	−21.1	8
Déc. 5	7 37 7	+0 29.99	− 0 10.1	9, 6	23 21 0.70	9.064	89 11 1.1	0.809n	+2.53	−19.1	9
6	7 11 1	+1 32.95	− 5 8.0	9, 9	23 25 3.65	9.122	89 36 36.5	0.808n	+2.52	−19.1	9
					(48) *Doris*						
Sept. 13	9 13 9	+0 36.58	− 6 41.6	6, 6	23 5 15.90	9.287n	92 45 7.1	0.827n	+3.05	−21.1	10
					(56) *Melete*						
Avril 17	9 18 15	+0 11.80	− 6 8.6	6, 1	11 15 41.45	8.281	87 55 10.1	0.795n	+1.59	+12.6	11
18	9 15 14	+0 15.79	− 6 21.2	9, 6	11 15 15.13	8.377	87 49 27.7	0.795n	+1.58	+12.5	11
Mai 3	9 35 51	−3 3.29	+ 9 30.3	9,10	11 11 37.71	9.065	86 36 1.3	0.786n	+1.43	+11.5	12
4	9 36 1	−3 5.79	+ 5 58.5	9,12	11 11 35.20	9.090	86 32 32.4	0.786n	+1.42	+11.4	12
					(60) *Echo*						
Oct. 31	7 31 10	−0 59.32	− 3 25.7	9, 6	23 11 50.72	9.048n	91 34 50.1	0.839n	+2.85	−20.2	13
Nov. 8	7 43 37	+0 38.14	8 53.1	9, 8	23 12 2.67	8.556n	91 17 58.2	0.842n	+2.75	−19.6	14
					(75) *Eurydice*						
Déc. 5	7 7 38	−2 16.13	− 3 8.3	9.12	23 21 21.35	8.847	91 50 5.6	0.823n	+2.52	−18.4	15
					(80) *Sappho*						
Avril 9	11 59 8	+3 51.53	+ 2 1.2	9, 9	15 14 58.16	9.327n	107 56 4.6	0.889n	+1.96	+ 1.0	16
Mai 1	11 15 26	−3 22.71	−10 36.7	9, 9	14 51 16.13	8.912n	101 57 8.9	0.890n	+2.27	+ 3.2	17
5	10 11 16	0 59.61	12 12.0	9, 6	14 50 19.83	9.261n	101 49 34.1	0.883n	+2.28	+ 3.4	18
Juin 7	10 35 26	0 14.59	0 28.7	9, 8	14 23 26.36	9.107	100 58 33.1	0.871n	+2.22	+ 4.4	19
8	10 51 26	0 13.21	− 5 22.3	9, 8	14 22 57.71	9.210	100 53 39.4	0.869n	+2.22	+ 4.3	19
9	10 46 13	−1 9.91	−10 3.4	9, 8	14 22 31.03	9.208	100 48 58.3	0.869n	+2.21	+ 4.3	19
					(83) *Beatrix*						
Nov. 8	7 6 16	−2 30.11	+10 11.9	9,12	23 6 55.41	8.961n	98 35 8.3	0.861n	+2.73	−18.6	20
					(89) *Julia*						
Sept. 7	9 1 9	+0 24.10	5 38.6	6, 8	19 18 10.51	8.182	109 8 34.5	0.907n	+2.87	−15.6	21
13	9 2 15	−0 16.51	− 9 37.5	6, 6	19 17 53.28	8.881	108 22 38.1	0.903n	+2.77	−15.6	22
					(107) *Camilla*						
Mars 16	10 59 7	−1 50.89	9 31.1	9,12	12 8 7.61	9.208n	89 18 31.0	0.810n	+1.71	+10.8	23
17	11 21 10	−0 51.03	0 18.0	9, 8	12 7 29.13	9.052n	89 11 52.8	0.809n	+1.72	+11.0	24
Avril 9	10 31 1	−2 0.83	1 51.7	9, 8	11 53 32.17	8.279n	87 15 30.9	0.790n	+1.72	+11.4	25
10	10 29 58	−1 29.56	7 29.3	9, 6	11 53 0.88	7.203n	87 9 56.3	0.787n	+1.70	+11.4	25
					(110) *Lydia*						
Févr. 9	7 33 2	1 8.77	2 33.2	6, 8	1 32 16.59	8.491	61 6 51.7	0.503n	+0.96	+ 5.6	26

Dates	T. m. Besançon	ΔA.R.	ΔD.P.	Cp.	A.R. app	log f.p.	D.P. app.	log f.p.	Réd. au j.		★
					(111) *Ate*						
1923	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Avril 18	10 11 27	−2 28.59	+15 6.8	9,12	12 25 10.97	8.721*n*	100 51 7.2	0.874*n*	+1.95	+11.5	27
Mai 3	10 13 15	+0 58.90	− 3 55.9	9, 8	12 16 30.89	8.848	99 12 4.2	0.867*n*	+1.81	+12.3	28
4	10 3 1	+0 35.88	− 7 59.5	9, 6	12 16 7.86	8.771	99 38 0.6	0.867*n*	+1.83	+12.3	28
					(117) *Lomia*						
Nov. 5	8 30 32	+0 36.04	+ 7 29.7	6, 3	0 32 23.73	9.071	73 2 5.3	0.652*n*	+3.41	−21.6	29
					(130) *Electra*						
Avril 9	10 3 32	+3 50.23	+ 7 9.3	9.12	11 54 10.99	8.889*n*	71 3 55.7	0.622*n*	+1.61	+ 9.0	30
10	9 57 49	+3 15.62	+ 2 40.2	9,12	11 53 36.39	9.902*n*	70 59 26.5	0.621*n*	+1.62	+ 8.9	30
					(177) *Irma*						
Dec. 6	8 10 5	−1 31.85	− 9 55.0	9, 8	0 53 30.14	8.117	82 31 34.0	0.751*n*	+3.44	−17.5	31
					(189) *Phthia*						
Mai 15	11 54 50	−3 7.39	+1 30.0	9.12	15 50 49.23	8.660*n*	105 16 52.4	0.893*n*	+2.37	− 0.6	32
					(211) *Isolda*						
Mars 16	9 48 50	−2 0.57	− 8 54.1	9, 8	8 56 57.22	8.660	77 12 48.3	0.703*n*	+1.39	+13.7	33
17	10 11 35	−2 16.04	−10 19.3	9, 8	8 56 41.74	8.994	77 40 53.0	0.705*n*	+1.38	+13.6	33
					(216) *Cleopatra*						
Juill 4	10 23 12	+0 52.17	− 0 5.4	9, 8	16 23 20.65	8.921	99 33 14.7	0.867*n*	+2.55	− 4.8	34
5	10 29 4	+0 19.32	− 1 14.9	6, 8	16 22 47.80	9.006	99 32 1.8	0.866*n*	+2.55	− 4.9	34
					(308) *Polyxo*						
Avril 10	11 5 56	+2 45.39	− 1 58.6	9,12	12 54 11.91	8.795*n*	91 0 22.4	0.857*n*	+1.89	+ 9.7	35
18	10 40 55	−1 7.98	+ 2 19.7	9, 8	12 48 27.13	8.612*n*	93 10 35.0	0.831*n*	+1.89	+ 9.7	36
Mai 3	10 35 41	−0 4.96	+ 4 18.1	9, 6	12 38 57.17	8.812	91 51 19.3	0.823*n*	+1.82	+ 9.6	37
4	10 24 19	−0 32.99	+ 0 19.2	9, 6	12 38 29.14	8.757	91 50 20.3	0.823*n*	+1.82	+ 9.5	37
Juin 8	9 56 40	−1 44.73	+ 7 32.5	9, 8	12 36 3.09	9.376	91 13 33.4	0.818*n*	+1.55	+ 7.3	38
9	10 1 6	−1 21.83	+ 9 20.3	9, 8	12 36 22.98	9.397	91 15 21.2	0.817*n*	+1.54	+ 7.3	38
					(322) *Phaeo*						
Oct. 30	7 36 13	−2 8.52	+ 8 58.5	9, 8	21 28 8.46	8.853	93 53 16.4	0.836*n*	+2.38	−21.2	39
31	8 3 32	−1 6.43	+ 8 41.6	9, 6	21 29 10.53	9.086	93 53 29.6	0.835*n*	+2.36	−21.1	39
					(409) *Aspasia*						
Oct. 30	8 5 7	+1 16.60	−13 5.9	9, 6	21 44 45.99	8.960	89 16 45.7	0.806*n*	+2.44	−22.6	40
31	8 30 51	+1 48.16	− 9 45.7	9, 8	21 45 17.51	9.147	89 20 5.9	0.806*n*	+2.43	−22.6	40
					(444) *Gyptis*						
Juill 1	11 8 26	+0 54.65	+ 1 13.0	9, 8	18 35 2.42	8.833*n*	96 17 35.0	0.850*n*	+2.71	−12.2	41
5	10 53 18	+0 52.47	+ 8 20.7	9, 8	18 34 11.09	8.935*n*	96 17 57.6	0.849*n*	+2.72	−12.3	42
					(451) *Patientia*						
Mai 15	11 21 0	+0 8.24	+ 4 35.2	9, 6	13 37 17.94	9.112	80 36 21.0	0.735*n*	+1.85	+ 1.1	43
Juin 7	10 13 11	+2 16.80	− 1 8.6	9, 8	13 28 49.71	9.255	82 10 9.0	0.753*n*	+1.70	+ 2.4	44
8	10 30 39	+2 8.12	+ 1 39.2	9, 8	13 28 41.05	9.328	82 15 56.7	0.756*n*	+1.69	+ 2.3	44
9	10 26 5	+2 23.88	− 3 11.3	9, 9	13 28 33.95	9.327	82 21 17.2	0.758*n*	+1.68	+ 2.3	45

Dates	Temps Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app	log f.p.	D.P. app.	log f.p.	Réd. au j.		★
				(488) *Kreusa*							
1923	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Févr. 9	8 4 31	1 16.21	+ 3 34.0	9, 8	4 34 9.34	8.908	67 11 49.8	0.562*n*	+0.92	+ 6.6	46
				(779) *Nina*							
Mars 16	10 20 58	0 56.57	+ 1 28.7	9, 8	9 45 44.49	8.833	89 31 11.6	0.808*n*	+1.48	+16.0	47
17	10 56 46	1 30.40	+ 0 46.1	9, 8	9 45 10.65	9.434	89 30 29.0	0.808*n*	+1.47	+16.0	47
				Comète 1923*b* (D'ARREST-REID)							
Déc. 6	6 51 55	0 33.28	+ 2 21.2	9, 6	22 53 56.30	9.020	144 8 41.2	0.916*n*	+2.22	− 11.2	48

Positions moyennes des étoiles de Comparaison.

★	A.R. 1923.0	D.P. 1923.0	Autorités		★	A.R. 1923.0	D.P. 1923.0	Autorités	
	h m s	° ′ ″				h m s	° ′ ″		
1	22 40 39.77	96 45 17.8	*A. G. Wien-Ottak*	7968	25	14 54 29.62	87 17 14.2	*A. G. Albany*	4375
2	15 54 9.43	103 43 16.2	*A. G. Camb. U. S.*	5539	26	4 36 24.40	64 9 19.3	*A. G. Camb. E*	2142
3	15 39 53.44	101 49 8.4	*A. G. Camb. U. S.*	5482	27	12 27 37.64	100 38 48.9	*A. G. Camb. U. S.*	4543
4	14 25 23.54	100 13 26.4	*A. G. Camb. U. S.*	5088	28	12 45 30.45	99 45 17.8	*A. G. Wien-Ottak*	4534
5	13 30 44.83	94 33 46.4	*A. G. Strasbourg*	4884	29	0 31 44.28	72 54 57.2	*rap à A. G. Berl A*	165
6	13 6 15.02	92 52 50.2	*A. G. Strasbourg*	4784	30	14 50 19.45	70 56 37.4	*rap à A. G. Berl A*	1540
7	22 59 14.92	90 56 48.9	*A. G. Nicolajew*	5770	31	0 54 58.85	82 44 46.5	*A. G. Leipzig II*	335
8	23 3 18.90	90 42 15.7	*A. G. Nicolajew*	5783	32	15 53 54.25	105 45 23.0	*A. G. Washington*	5828
9	23 23 28.48	89 42 3.6	*A. G. Nicolajew*	5828	33	8 58 56.40	77 51 28.7	*rap à A. G. Lpz I*	3645
10	23 5 6.27	92 52 9.8	*Abbadia*	13404	34	16 22 25.93	99 33 24.6	*A. G. Wien-Ottak*	5704
11	14 44 58.06	87 55 56.4	*A. G. Albany*	4243	35	12 54 24.75	94 5 14.3	*A. G. Strasbourg*	4708
12	14 44 39.57	86 26 22.5	*A. G. Albany*	4240	36	12 49 33.22	93 8 5.6	*A. G. Strasbourg*	4704
13	23 12 47.49	94 38 36.3	*A. G. Strasbourg*	8045	37	12 39 0.34	94 49 51.6	*A. G. Nicolajew*	3450
14	23 11 24.78	94 57 10.9	*A. G. Strasbourg*	8008	38	12 37 46.27	94 5 53.6	*A. G. Nicolajew*	3445
15	23 24 1.96	94 53 32.3	*A. G. Strasbourg*	8059	39	21 30 44.60	93 45 9.4	*A. G. Strasbourg*	7541
16	15 8 4.67	107 48 2.4	*A. G. Washington*	5597	40	21 43 26.95	89 30 14.2	*A. G. Nicolajew*	5510
17	14 54 36.57	105 7 12.4	*A. G. Washington*	5529	41	18 34 5.06	96 16 4.2	*A. G. Wien-Ottak*	6247
18	14 54 17.46	105 4 12.7	*A. G. Washington*	5508	42	18 33 15.90	96 9 19.2	*A. G. Wien-Ottak*	6238
19	14 23 38.73	100 58 57.4	*A. G. Camb. U. S.*	5084	43	13 37 7.85	80 34 14.7	*A. G. Leipzig II*	6477
20	23 9 22.55	98 24 15.6	*A. G. Wien-Ottak*	8244	44	13 26 34.24	82 44 15.2	*A. G. Leipzig II*	6424
21	19 47 43.54	109 44 28.7	*Paris*	26983	45	13 26 8.39	82 25 26.2	*A. G. Leipzig II*	6424
22	19 48 7.05	108 32 31.2	*Bordeaux*	5992	46	4 35 24.63	67 8 9.2	*A. G. Berlin B*	1484
23	12 9 56.79	89 57 54.3	*A. G. Nicolajew*	3378	47	9 46 39.58	89 29 26.9	*A. G. Nicolajew*	2850
24	12 8 19.04	89 44 59.8	*A. G. Nicolajew*	3372	48	22 54 27.36	144 6 31.2	*Cordoba A*	15461

REMARQUES

Planètes. — (56) Avril 17, le ciel se couvre rapidement. (447) Novembre 5, arrêt des mesures, épais nuages.

Comète 1923*b* (D'ARREST-REID): Décembre 6, la Comète de 12.5 à 13 grandeur, apparaît comme une petite nébulosité floue, de 20″ au plus de diamètre, sans noyau bien défini. Les mesures sont pénibles. Pour notre latitude, l'aspect de cet astre est certainement modifié étant donné sa proximité de l'horizon brumeux.

Observatoire de Besançon,
5 Juin, 1924.

CONTENTS

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No. 840

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PARALLAXES OF FIFTY STARS,

DETERMINED BY PHOTOGRAPHY WITH THE 26-INCH MCCORMICK REFRACTOR,

By CHARLES P. OLIVIER.

The list of parallaxes is in continuation of those given in the *Astronomical Journal* Nos. 778, 796, 803, 808, 823 and 824. An asterisk in the first column is to indicate that the measures on the star were completed by Director S. A. MITCHELL and prepared for solution by least squares while the writer was on leave of absence for the year from the McCormick Observatory. As usual the solutions were carried out by MISS EUDORA MAGILL. In the values of the proper motions, the letter C indicates that the result is taken from *Cincinnati Publications*, No. 18, instead of from Boss. The parallaxes given are relative to the mean parallax of the comparison stars of about the tenth magnitude.

Leander McCormick Observatory, University of Virginia,
February 29, 1924.

No.	Star	1900 R. A.	1900 Decl.	Magnitude and Spectrum	Proper-motion Total	Right Ascension Boss	Right Ascension Observed	Relative Parallax	
		h m	° ′		″	″	″	″	″
525*	*γ Pegasi*	0 8.1	+14 38	2.9 B2	0.013	.000	−.015	−.007	±.012
527	*ζ Andromedae*	0 42 0	+23 43	4.3 K0	0.129	−.102	−.148	+.037	9
528	*γ Cassiopeiae*	0 50.7	+60 41	2.2 B0p	0.030	+.030	+.003	+.033	8
529	*υ Persei*	1 31.9	+48 7	7.8 K0	0.127	+.064	+.057	−.007	10
530	B. D. +63°224	1 35.7	+63 24	7.7 K0			−.014	+.032	8
531	*AOe* 1867–8	1 36.7	+63 22	8.2 K2	0.70	−.397C	−.418	+.078	7
532	*β Arietis*	1 49.1	+20 19	2.7 A5	0.147	+.096	+.151	+.091	12
533	31 *Arietis*	2 31.2	+12 1	5.7 F5	0.297	+.285	+.266	+.012	10
534	30¹ *Arietis*	2 31.2	+24 13	7.4 F5	0.152	+.152	+.125	+.018	11
535	30² *Arietis*	2 31.2	+24 13	6.6 F5	0.140	+.140	+.105	+.009	12
536	*Lalande* 4855	2 32.7	+30 25	7.2 G0	0.625	−.489C	−.481	+.034	10
537	*θ¹ Tauri*	4 22.8	+15 41	4.0 K0	0.108	+.104	+.087	+.032	10
538	*θ² Tauri*	4 22.9	+15 39	3.6 F0	0.107	+.104	+.078	+.023	10
539	58 *Persei*	4 29.7	+41 4	4.5 G1p	0.025	−.006	+.020	+.023	8
540	*π⁴ Orionis*	4 45.9	+ 5 26	3.8 B3	0.007	−.004	+.012	+.004	8
541*	9 *Orionis*	4 50.7	+13 24	4.3 K0	0.103	−.082	−.080	+.015	10
542	*β Eridani*	5 2.9	− 5 13	2.9 A3	0.119	−.088	−.072	+.019	9
543	*W. B.* 5ʰ 87	5 7.4	− 9 12	8.0 K0	0.57	−.059C	−.094	+.054	9
544	*ζ Tauri*	5 31.7	+21 5	3.0 B3p	0.028	+.003	+.013	−.006	8
545	*σ Orionis*	5 33.7	− 2 39	3.8 B0	0.001	.000	−.003	−.014	7

No.	Star	1900 R. A.	1900 Decl.	Magnitude and Spectrum	Proper-motion Total	Proper-motion Right Ascension Boss	Proper-motion Right Ascension Observed	Relative Parallax	
		h m	° ′		″	″	″	″	″
546	*γ Monocerotis*	6 10.0	− 6 14	4.1 K0	0.021	−.001	−.009	+.009	±.006
547	*T Monocerotis*	6 19.8	+ 7 8	6.2 G5p	0.029		−.009	−.012	8
548	*θ Geminorum*	6 46.2	+34 5	3.6 A2	0.055	+.006	−.001	+.014	8
549	*Lalande* 13912	7 8.4	+17 25	5.6 G0	0.481	+.039	+.057	+.020	9
550	*Lalande* 18286	9 12.0	+29 0	7.3 K0	0.517	+.070C	+.059	+.019	8
551	*Lalande* 19022	9 37.2	+13 11	8.4 K2	0.849	+.042C	−.004	+.066	8
552	*μ Leonis*	9 47.1	+26 29	4.1 K0	0.227	−.219	−.223	+.015	7
553	*λ Ursae Majoris*	10 11.1	+43 25	3.5 A2	0.168	−.162	−.153	−.013	11
554	*θ Leonis*	11 9.0	+15 59	3.4 A0	0.106	−.064	−.015	+.010	8
555	*γ Crateris*	11 19.9	−17 8	4.1 A5	0.107	−.107	−.063	+.025	11
556	*σ Bootis*	14 30.3	+30 14	4.5 F0	0.228	+.193	+.208	+.028	10
557	*Lalande* 27026	14 46.0	−23 52	7.7 K2	1.022	−.928C	−.929	+.080	10
558	*W. B.* 15h 268	15 17.7	+ 1 47	8.7 K6	0.507	−.369C	−.346	+.030	15
559	*δ Serpentis*	15 30.0	+10 53	4.2 F0	0.068	−.068	−.056	+.006	8
560	*λ Serpentis*	15 41.6	+ 7 40	4.4 G0	0.244	−.235	−.218	+.090	12
561	*ε Herculis*	16 56.5	+31 4	3.9 A0	0.050	−.046	−.055	+.064	9
563	*θ Herculis*	17 52.8	+37 16	4.0 K0	0.006	+.003	+.022	−.003	7
564	*ν Herculis*	17 54.7	+30 11	4.5 F0	0.004	+.004	−.023	+.004	10
565	67 *Ophiuchi*	17 55.6	+ 2 56	3.9 B5p	0.014	+.004	−.004	−.004	12
566	*ε Aquilae*	18 55.1	+14 56	4.2 K0	0.100	−.064	−.082	+.017	9
567	*λ Aquilae*	19 0.9	− 5 2	3.6 B9	0.093	−.025	+.020	+.034	9
568	*θ Aquilae*	20 6.1	− 1 7	3.4 A0	0.034	+.034	+.014	+.011	11
569	*Groombridge* 3357	20 56.1	+39 51	6.6 F8	0.344	+.230C	+.269	+.007	12
570	*Lalande* 42128	21 33.0	− 2 15	8.8 G5	0.566	+.504C	+.467	+.027	16
571	*γ Aquarii*	22 16.5	− 1 53	4.0 A0	0.123	+.123	+.110	+.060	7
572	*ζ Pegasi*	22 36.4	+10 18	3.6 B8	0.078	+.077	+.065	−.006	14
573	*ο Andromedae*	22 57.3	+41 47	3.6 B3	0.031	+.023	+.013	−.004	10
574	86 *Aquarii*	23 1.3	−24 17	4.8 G5	0.068	+.068	+.039	−.003	5
575	*Lalande* 46495	23 38.5	+57 30	7.0 G2	0.610	+.380C	+.391	−.020	7
576	*Pi* 23h 267	23 59.7	+31 6	6.2 G4	0.766	+.761C	+.801	+.036	12

ORBIT OF THE FIFTH SATELLITE OF *JUPITER*.

By JAMES ROBERTSON.

(Communicated by Captain Edwin T. Pollock, U. S. Navy, Superintendent United States Naval Observatory.)

The determination of the orbit of this Satellite is based on Lick and Yerkes Observations by E. E. Barnard, published in the *Astronomical Journal*, Vol. XII, pages 81-85 and 161-173. They are referred to the observed positions of the belts of *Jupiter* as given therein. The observations were divided into groups, the duration of each group not exceeding six minutes, and the correction for aberration applied to the mean time of each group. After 13 observations were rejected for various and obvious reasons, 300 groups were formed from 1294 observations.

The following notation is used:

P = Position-angle of satellite when in superior conjunction.

U = Angle at the planet between the node and the semi-axis minor of the apparent eclipse.

B = Angle between the plane of the orbit of satellite and the line from observer to planet.
N = Ascending node of orbit of satellite on Equator.
J = Inclination of orbit of satellite to Equator.
u = True angular distance of satellite from ascending node.
u_0 = Value of u at epoch.
e = Eccentricity of orbit of satellite.
ω = Planetocentric angular distance of pericenter of satellite from ascending node.
a = Semi-axis major of orbit of satellite (at distance 5.2).
n = Mean motion of satellite.
ρ = Distance from *Earth* to planet.
ρ_0 = Distance for which a is taken.
r = Radius vector of satellite as seen at distance ρ.
r_0 = a when $e = 0$
r_1 = $\frac{\rho_0 r_0}{\rho}[1 - \sin r \cos B \cos (u-U)]$
p = Position-angle of satellite.
s = Angular distance of satellite from planet as seen from *Earth*.
α, δ = Right-ascension and declination of planet.
G = Angle between the projection of the meridian and the projection of the major axis upon the apparent ellipse.
h = $57.3e \sin \omega$
k = $57.3e \cos \omega$

The rectangular coördinates used in forming the residuals were computed from the following formulae*:

$$\begin{aligned}
\cos B \cos U &= \cos \delta \cos (\alpha - N)\\
\cos B \sin U &= \sin \delta \sin J + \cos \delta \cos J \sin (\alpha - N)\\
\sin B &= -\sin \delta \cos J + \cos \delta \sin J \sin (\alpha - N)\\
\cos B \sin P &= -\sin J \cos (\alpha - N)\\
\cos B \cos P &= \cos \delta \cos J + \sin \delta \sin J \sin (\alpha - N)\\
r_1 &= \frac{\rho_0 r_0}{\rho}\\
s \sin (p-P) &= r_0 \sin (u-U)\\
s \cos (p-P) &= r_0 \sin B \cos (u-U)\\
x &= s \cos (G-p)\\
y &= s \sin (G-p)
\end{aligned}$$

Precession, nutation, parallax and the last term in the value of r_1, were found to be negligible. The observed values of G recorded by BARNARD are used. The coordinates of *Jupiter* were taken from the *American Ephemeris*.

The following differential formulae were used for computing the equations of condition.

$$\begin{aligned}
\delta s = \frac{s}{57.3}\Bigg[&\frac{\cos^2 (p-P) \sin U}{\tan B} + \frac{\cos B \sin 2 (p-P) \cos U}{2}\Bigg]\delta J\\
+ \frac{s}{57.3}\Bigg[&\frac{\sin 2 (p-P) \cos \delta \cos P}{2 \tan B} - \frac{\cos^2 (p-P) \sin J \cos U}{\tan B}\Bigg]\delta N\\
+ \frac{s}{57.3}&\,\frac{\cos B \sin 2 (p-P)}{2 \tan B}\,\delta u_0 + \frac{s}{r_0}\,\delta r_0\\
- \frac{s}{57.3}\Bigg[&\frac{\cos B \sin 2 (p-P) \cos u}{\tan B} + \sin u\Bigg]h\\
+ \frac{s}{57.3}\Bigg[&\frac{\cos B \sin 2 (p-P) \sin u}{\tan B} - \cos u\Bigg]k
\end{aligned}$$

$$\begin{aligned}
\delta p = \frac{1}{57.3}\Bigg[&\frac{r^2}{\rho^2 s^2} \sin B \tan B \cos U - \frac{\sin 2(p-P) \sin U}{2 \tan B} - \frac{\cos U}{\cos B}\Bigg]\delta J\\
+ \frac{1}{57.3}\Bigg[&\frac{r^2}{\rho^2 s^2} \tan B \cos \delta \cos P + \frac{\sin 2 (p-P) \sin J \cos U}{2 \tan B} - \frac{\sin J \sin U}{\cos B}\Bigg]\delta N\\
- \frac{1}{57.3}&\,\frac{r^2}{\rho^2 s^2} \sin B\, \delta u_0 - \frac{2}{57.3}\,\frac{r^2}{\rho^2 s^2} \sin B \cos u\, h\\
+ \frac{2}{57.3}&\,\frac{r^2}{\rho^2 s^2} \sin B \sin u\, k
\end{aligned}$$

$$\delta x = \frac{x}{s}\,\delta s + y\,\delta p\,, \quad \delta y = \frac{y}{s}\,\delta s - x\,\delta p$$

These formulae are not as convenient as those used by WALTER S. HARSHMAN or HERMANN STRUVE, but as the work was well advanced before their formulae were published, for the sake of continuity no change was made. Advantage was taken, however, of the opportunity to check the formulae used by me by transforming them into those given by HARSHMAN and STRUVE.

The computation was based on the following provisional elements: The orbit being assumed as circular:

Epoch = 1892 Oct. 11.0 G.M.T.
Period = $0^d.4981798$
a = $47''.88$ (at distance 5.2)
J = $25° \; 12'.4$
N = $358° \; 58'.9$
u = $315° \; 11'.16$

The following are the normal equations:

* MARTH, *Monthly Notices*, Vol. 47.

δJ	δN	δu_0	h	k	δr_0		
28.7802	+ 3.1410	− 1.5151	− 0.5851	− 1.9590	− 2.2769	=	− 9.2085
	35.7713	+ 34.0124	+ 50.0907	− 4.0158	− 5.7793	=	− 23.1876
		38.2483	+ 56.2202	− 3.6183	− 5.1103	=	− 21.3362
			343.5018	− 105.4626	− 147.2051	=	− 67.7068
				65.0655	+ 34.6801	=	+ 15.5619
					362.7252	=	+ 19.2606

The solution of the normal equations gives:

$$\begin{aligned}
\delta J &= -0^\circ.25353 \pm 0^\circ.0183 \\
\delta N &= -0^\circ.55468 \pm 0^\circ.1109 \\
\delta u_0 &= +0^\circ.16763 \pm 0^\circ.1134 \\
h &= -0^\circ.17018 \pm 0^\circ.0261 \\
k &= -0^\circ.05935 \pm 0^\circ.0479 \\
\delta r &= -0''.01836 \pm 0''.0144
\end{aligned}$$

Substituting the above values of h and k in the formulae:

$$\begin{aligned}
57.3e \sin\omega &= h \\
57.3\, e \cos\omega &= k
\end{aligned}$$

we find

$$\begin{aligned}
e &= 0.00315 \quad \pm 0.00102 \\
\omega &= 250^\circ\ 46'.4 \quad \pm 3^\circ\ 23'.8
\end{aligned}$$

The precession of the node was found from the following formulae:

$$\begin{aligned}
\Delta J &= \cos N\ \Delta\epsilon - \sin N \sin\epsilon\ \Delta\psi \\
\Delta N &= -\sin N \cot J\ \Delta\epsilon - \cos N \sin\epsilon \cot J\ \Delta\psi + \cos\epsilon\ \Delta\psi \\
\Delta\epsilon &= -0''.4681 \\
\Delta\psi &= +50''.256
\end{aligned}$$

The values of $\Delta\epsilon$ and $\Delta\psi$ are taken from the American Ephemeris. From this we find:

$$\begin{aligned}
\Delta J &= +0'.0013\,(t - 1892.8) \quad (t \text{ is in units of years.}) \\
\Delta N &= +0'.0679\,(t - 1892.8)
\end{aligned}$$

Applying these corrections to the assumed elements we have the following elliptic elements:

Epoch = 1892 Oct. 14.0 G.M.T.
Period = $0^d.498179$

$$\begin{aligned}
n &= 722^\circ.63176 \\
a &= 17''.8616 \pm 0''.0141 \text{ (at distance 5.2)} \\
J &= 25^\circ\ 27'.2 + 0'.0013\,(t - 1892.8) \\
N &= 358^\circ\ 25'.6 + 0'.0679\,(t - 1892.8) \\
u &= 315^\circ\ 54'.22 \\
e &= 0.00315 \pm 0.00102 \\
\omega &= 250^\circ\ 46'.4 \pm 3^\circ\ 23'.8
\end{aligned}$$

The sum of the squares of the residuals derived from the equations of condition is 37.233 and the number of equations 300, therefore the probable error of a single group of observations is ± 0.240. From the quantity $[\Delta\Delta 6]$ = 37.233 we also find the probable error of a group of observations is ± 0.240.

The action of the *Sun* on the position of ω is expressed approximately as follows:

$$\Delta\omega = \tfrac{3}{4} n \left(\frac{t}{t_0}\right)^2 (1 + \cos^2 J) \ *$$

where n = mean motion of satellite
t = periodic time of satellite
t_0 = periodic time of planet
J = inclination of orbit of satellite to equator

Solving this equation we find:

$$\Delta\omega = 0^\circ.00475 \text{ per year}$$

From this we conclude that the action of the *Sun* on ω is so small that we can safely neglect it.

As the nearest other satellite (*Satellite I*) is over twice as far from *Jupiter* and has a mass of only 0.000017 that of *Jupiter* we can safely neglect the action of the other satellite on the position of ω.

If we assume that *Jupiter* is composed of homogeneous spheroidal shells the motion of the pericenter caused by the flattening at the poles is expressed by:

$$\Delta\omega = n \left(\frac{a_e}{a}\right)^2 \left[1 + \frac{1}{e}\cos(u - \omega) + \ldots\right] J$$

where n = daily motion of satellite
a_e = equatorial radius of *Jupiter*
a = semi-major axis of orbit of satellite
e = eccentricity of orbit of satellite
u = mean longitude of satellite
ω = longitude of pericenter
J_1 = the accelerating constant (Its value 0.02190 is taken from Laplace)†.

* Harshman, *Astronomical Journal No. 331.*

† *Mécanique Céleste*, 2nd Part, Book VIII, Chapter IX.

From solving this equation we find:

$\Delta\omega$ = 2°.478 per day (In this solution a_c = 18″.91 at distance 5.2 and n = 722°.63)

A comparison of the above longitude of the pericenter with that derived by Miss E. E. Dobbin from observations made in 1902‡ shows an apparent motion of the pericenter of 2°.484 per day. This value differs only 0°.006 from the value obtained theoretically given above. (Miss Dobbin made four determinations of the longitude of the pericenter from four different groups of observations. I selected the results of the third determination because the probable error of ω in this group was less than in the first and fourth groups and she refers to the value of e in the second group as unsatisfactory. Also because I had made use of these observations several years ago for another purpose and I found the third group the most reliable.)

Tisserand developed a theory of the motion of this satellite and published his determination of its elements Oct. 8, 1894§. He found the value of ω for Nov. 1.0, 1892 to be 356° with a motion of + 882° per year or 2°.42 per day.

‡ *Astronomical Journal*, No. 562.
§ *Comptes Rendus*, Vol. 119.

Dr. Fritz Cohn, after an elaborate investigation of the orbit of this satellite, published his determination of its elements Sept. 11, 1896. He found the value of ω for Nov. 1.0, 1892 to be 207°.2 with a motion of 911°.7 per year or 2°.50 per day||.

It is to be noted that the determinations of Tisserand and Cohn differ 149° for the longitude of ω, and 30° in its motion per year.

I first derived the elements of this satellite in 1893 from observations furnished in manuscript by E. E. Barnard. These were adopted by the American Ephemeris, and after 1911 by the Connaissance des Temps. When a more extended group of observations was published in January 1893, a redetermination of the elements was begun. The work was well advanced when Dr. Cohn published his elaborate discussion of this orbit Sept. 11, 1896. After this publication it did not seem necessary to complete the discussion. But when E. E. Barnard published his article on this orbit, I thought that my discussion should be finished.

|| *Astronomische Nachrichten*, Nos. 3403-4.

U. S. Naval Observatory, Washington, D. C.,
1923, Dec. 3.

OBSERVATION OF THE TRANSIT OF *MERCURY* ON MAY 7, 1924.

[Communicated by R. A. Rossiter.]

The ingress of *Mercury* was observed at Ann Arbor with the 12¼-inch refractor of the Detroit Observatory fitted with a polarizing helioscope. The Ann Arbor sidereal time of exterior tangency was 7 hours 9 minutes 3.4 seconds; of interior tangency, 7 hours 11 minutes 50.5 seconds. A lag of probably 8 or 10 seconds occurred in observing the instant of exterior contact, but the error in observing the instant of interior contact was certainly not over 3 seconds.

The observation was made by Assistant Professor R. A. Rossiter, the times recorded by Professor W. J. Hussey and Mr. H. F. Schiefer.

Detroit Observatory Ann Arbor, Michigan,
May 27, 1924.

OBSERVATIONS OF *NOVA CYGNI*, 1920,

MADE AT THE LEANDER MCCORMICK OBSERVATORY,

By HAROLD L. ALDEN and OTHERS.

The following observations of the visual magnitude of *Nova Cygni*, 1920, have been made for the most part by the writer. The observations made by other members of the staff of the McCormick Observatory have been included because they were too few to justify separate publication. The name of the observer is given in the column headed "Remarks," the absence of a name indicating that the writer is responsible for the observation. Estimates of the brightness of the *Nova* made by Dr. Olivier during the summer following its appearance have not been included.

Harvard magnitudes of the comparison stars have been used in the reduction. For the brighter stars, the magnitudes have been taken from the Harvard Annals. The magnitudes of the fainter comparison stars are based on measures by Mr. Leon Campbell with the twelve-inch meridian photometer and were kindly supplied by him in advance of publication. These were adjusted slightly to conform to the relative magnitude as seen in the twenty-six inch refractor. The number of comparison stars appearing in the record of the observation is given in the fourth column.

The observations prior to September 4, 1920, were

made with the naked eye. From September 10 to 25, 1920 a low power field glass was used. All subsequent observations were made with a six-inch telescope, the five-inch finder or the twenty-six inch refractor. The observations to September 24, 1920 have appeared in the report of the American Association of Variable Star Observers for November, 1920, in *Popular Astronomy*.

Leander McCormick Observatory, University, Virginia, March 5, 1924.

OBSERVATIONS OF *NOVA CYGNI*, 1920

Date	J. D.	Magn.	No. of Stars	Remarks
1920	2,422,000+			
Aug. 24	561.8	2.2	5	Haze
25	562.5	2.6	2	Haze
	562.7	2.5	2	Clear
26	563.5	2.8	3	Clouds
	563.8	2.9	2	Clear
28	565.8	3.6	5	
30	567.5	4.0	1	
Sept. 1	569.7	4.2	3	
2	570.6	4.4	3	
3	571.6	4.5	2	
4	572.6	4.6	4	
10	578.6	5.3	3	
11	579.5	5.4	2	
12	580.5	5.3	3	
13	581.5	5.8	2	
14	582.6	5.8	2	
15	583.7	5.7	4	
16	584.5	6.0	3	
17	585.6	6.0	1	
18	586.6	5.9	2	
20	588.6	6.2	3	
21	589.5	6.1	2	
22	590.6	6.4	1	
24	592.5	6.5	1	
25	593.6	6.6	1	
Oct. 4	602.6	8.1	2	
9	607.5	8.4	1	
15	613.6	8.8	3	
22	620.6	9.3	2	
Nov. 3	632.7	9.1	3	
20	649.6	9.2	4	
Dec. 14	673.6	9.0	4	
1921				
Feb. 15	736.9	9.3	6	
Mar. 16	765.9	9.5	7	
May 19	829.8	9.9		Olivier
May 31	841.8	9.4	2	

Date	J. D.	Magn.	No. of Stars	Remarks
1921	2,422,000+			
Sept. 7	940.7	9.8	2	
Oct. 10	973.5	9.9	3	
Oct. 13	976.5	10.0	1	
1922	2,423,000+			
June 23	229.8	11.1	3	Olivier
Aug. 6	273.6	10.8	5	
23	290.6	10.5	1	
Sept. 14	312.7	11.0	3	Mitchell
15	313.7	11.0	5	
22	320.6	11.1	5	
26	324.7	11.3	3	Mitchell
Oct. 5	333.5	10.9	5	
24	352.6	10.9	5	
Nov. 5	364.6	11.2	3	Mitchell
16	375.6	11.1	3	
19	378.6	10.6	2	
Dec. 23	412.5	10.8	4	
1923				
Jan. 16	436.0	10.4	3	
Mar. 19	498.9	11.0	5	
May 1	541.8	11.0	3	Mitchell
June 8	579.8	11.2	4	
July 20	621.8	11.4	3	
Aug. 14	646.6	11.4	3	
Sept. 16	679.7	11.5	3	
Oct. 6	699.7	11.9	4	Mitchell
15	708.7	11.2	1	
15	708.7	11.2	2	Robinson
17	710.6	11.9	4	Mitchell
21	714.5	11.4	8	
26	719.7	12.0	4	Mitchell
Nov. 1	725.6	12.0	6	Vyssotsky
1	725.6	11.6	6	
10	734.6	11.1	5	
Dec. 3	757.6	11.6	6	
11	765.7	11.5	5	

ERRATA TO OBSERVATIONS OF COMET 1922*c* (BAADE).

p. 101, line 14, for 12.85 read 12.87 and for 18.5 read 19.4

– 3, instead of note on Jan. 17 read "In the *Astr. Bor.* +17.2324, for $A = -1.9235$ read -0.9235."

p. 102, star 20, for 2.20 read 2.22 and for 49.7 read 50.6.

PARALLAXES OF THIRTY-THREE STARS,

FROM PLATES TAKEN WITH THE 40 INCH REFRACTOR OF THE YERKES OBSERVATORY

By OLIVER J. LEE AND GEORGE VAN BIESBROECK.

The following parallaxes have been obtained in the last few years in intervals of time that could be spared from other investigations. Many of these fields are such as have been carried along for some longer time than is usually the case because better conditions of "seeing" or longer exposures were required. Very often in such cases, when there is no choice, the arrangement of the comparison stars is far from ideal. In consequence our average probable error is larger than usual, ± ″.0108. On the average 13.8 plates and 4.5 comparison stars were used in each field. Eleven parallaxes in this list were gotten by MR. VAN BIESBROECK and twenty-two by MR. LEE.

A later Publication of the Yerkes Observatory will contain further details. The number of parallaxes published from Yerkes, including this list, is 258. The proper-motion given is the annual proper-motion in Right Ascension as obtained from the solutions.

Name	α 1900	δ 1900	*B.D.* No.	Mag.	Spec.	Proper-Motion	π	p. e.	No. pl.	No. of Cp.St.	Mean Mag.
	h m	° ′	°			s	″	″			
θ Cassiopeiae	1 5	51 37	+51 236	4.5	*A5*	+.022	+.608	±.008	17	5	10.8
β Arietis	1 49	20 19	+20 306	2.7	*A5*	+.008	+.037	.013	13	4	11
ρ² Arietis	2 50	17 56	+17 457	5.9	*Mb*	−.001	+.014	.013	12	3	11
B.G.C. 2381	4 46	10 54	+10 651	7.4	*F5*	+.001	+.045	.008	13	4	10.5
Σ612 (1)	4 49	7 13		8.5	...	+.018	+.026	.010	13	5	11
Σ612 (2)	4 49	7 13		8.8	.	+.016	+.036	.009	13	5	11
Mean			+ 7 754		*K0*		+.032	.007			
B.D. 21° 1079	5 55	21 1	+21 1079	10.7		.000	+.019	.010	10	5	10
B.G.C. 3499 *A*	6 32	12 16	+12 1219	8.4	*G5*	−.007	+.032	.018	12	1	10.5
C	6 32	12 14	+12 1222	8.8	*F8*	−.003	−.002	.016	12	1	10.5
B.D. 12° 1228	6 33	12 11	+12 1228	9.7		−.001	+.012	.011	12	3	10.7
B.D. 20° 1940	7 18	20 41	+20 1910	10.5		+.002	−.001	.016	11	5	10.9
B.D. 25° 1848	8 1	25 48	+25 1848	9.3		−.006	+.025	.009	17	5	9.9
B.D. 25° 1849	8 1	25 46	+25 1849	10.6		.000	−.008	.009	16	5	9.9
Lal 29439	16 3	38 55	+38 2726	8.5		+.021	+.063	.015	16	1	11
W 17ʰ 627	17 23	31 9	+31 3025	9.1		−.027	+.049	.011	16	5	10.8
Lal 31822	17 23	31 10	+31 3027	8.6	*F8*	−.027	+.034	.006	16	5	10.8
β Ophiuchi	17 39	4 37	+ 4 3489	2.9	*K*	−.001	+.023	.007	16	1	10.5
30 *Draconis*	17 47	50 48	+50 2468	5.2	*A*	.006	+.001	.010	14	1	10.5
99 *Herculis*	18 3	30 33	+30 3128	5.2	*F8*	−.010	+.070	.007	14	4	10.5
Nova Aquilae (1918)	18 44	0 28				.000	−.014	.006	13	5	10.5
B.D. −15° 5243	19 2	−15 23	−15 5243	9.8		−.008	+.010	.008	13	3	9.6
β Cygni	19 27	27 45	+27 3410	3.2	*K0*	.000	+.019	.008	17	6	10.5
17 *χ Cygni*	19 43	33 30	+33 3587	5.0	*F5*	+.002	+.056	.007	13	5	10.5
B.D. 36° 3883	20 1	36 17	+36 5883	7.4		.000	.000	.013	13	6	11
B.D. 5° 4556	20 30	5 17	+ 5 4556	8.2	*K2*	+.029	+.029	.015	13	5	10
α Cygni	20 38	44 55	+44 3541	1.3	*A2p*	+.001	.043	.011	12	1	10
δ Equulei	21 48	6 23	+ 6 4811	5.1	*A*	+.602	+.079	.012	11	3	10.2
Lal 42428	21 33	− 2 45	− 2 5588	8.7		−.030	+.056	.007	14	5	9.9
W.B. 22ʰ82	22 6	22 45	+22 4567	8.8		−.011	+.033	.008	11	5	10.8
33 *Pegasi*	22 19	20 21	+20 5139	6.1	*G*	+.023	+.008	.010	15	6	10.8
55 *ξ¹ Aquarii*	22 21	− 0 32		4.6		+.012	+.029	.010	15	5	10.3
55 *ξ² Aquarii*	22 21	− 0 32		4.2		+.012	+.021	.013	15	5	10.3
Mean			− 0 4365		*F5*		+.026	.008			
α Pegasi	23 00	14 40	+14 4926	2.6	*A*	+.001	+.060	±.012	20	4	10.7

OBSERVATIONS OF (433) *EROS*,

WITH THE 26-INCH REFRACTOR OF THE U. S. NAVAL OBSERVATORY,

BY ASAPH HALL AND ERNEST CLARE BOWER.

[Communicated by CAPT. EDWIN T. POLLOCK, U. S. Navy, Superintendent.]

G. M. T.	App. α	App. δ	Obj. − ★		Comp.	log pρ		Ap. pl. red. of ★		Seeing	Obs.	★
	h m s	° ′ ″	m s	′ ″				s	″			
1923 Oct. 13.81536	7 33 12.63	+38 37 32.4	+0 5.25	+ 7 22.2	d10, 8	9.681n	0.267	+2.36	−18.5	g	HI	1
16.85591	7 16 30.78	+38 12 39.1	−0 51.91	+12 58.1	d10, 8	9.579n	0.015	+2.35	−19.1	g	HI	2,3
Nov. 2.84301	8 56 16.38	+34 12 16.2	+0 18.01	− 0 53.9	d10, 9	9.666n	0.388	+2.23	−21.4	g	B	4
9.82393	9 23 31.38	+31 12 38.5	−0 13.80	− 0 23.5	d10, 8	9.632n	0.399	+2.17	−21.9	f	B	5
14.79932	9 12 11.69	+29 39 10.1	−0 20.19	− 7 6.6	d10, 8	9.665n	0.500	+2.19	−22.2	f	B	6
Dec. 14.85013	11 19 50.16	+12 15 52.1	−0 21.90	− 6 51.2	d10, 8	9.460	0.620	+2.45	−20.9	p	B	7
1924 Jan. 14.81888	12 34 11.65	− 9 42 52.5	+4 11.11	+ 2 11.4	t29, 6	9.419n	0.802	+0.15	+ 3.1	g	B	8
18.82747	12 11 18.13	−12 42 11.6	+1 50.38	+ 0 16.8	t30, 6	9.398n	0.822	+0.24	+ 3.7	p	B	9
26.87974	12 55 31.29	−18 38 33.0	−3 29.12	+ 1 28.1	t30, 6	8.870n	0.868	+0.45	+ 4.8	vp	B	10
Feb. 6.87077	13 10 6.33	−26 21 29.6	+2 52.46	− 6 11.2	t25, 5	8.639n	0.901	+0.85	+ 5.2	p	B	11
8.85383	13 12 7.88	−27 40 53.8	−0 10.24	− 1 10.6	d10, 8	8.933n	0.904	+0.89	+ 5.5	p	B	12

Oct. 16. Star 2 was used in α, and star 3 in δ. Nov. 2. Used step star. Dec. 14. Poor observation. Jan. 26. Poor observation.

Mean Places of Comparison Stars for Beginning of Year

★	α	δ	Authority	★	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	7 33 35.02	+38 30 28.7	*AG Lund* 3934	7	11 20 9.61	+12 53 7.2	*Astr Bor* +14.1120, 53
2	7 17 23.34	+38 8 20.4	*BD*+38 1828 comp. with 3, 1924 Apr. 8, Δα = +15.65, Δδ = +8′20″.0, 1923.0	8	12 29 30.09	− 9 15 7.0	*AG Wien Ottakring* 4589
				9	12 39 57.81	−12 43 32.1	*AG Harvard* 4602
				10	12 59 0.26	−18 10 6.2	*Astr Hyd* −18.1256, 36165; −19.1300, 38839
3	7 46 37.69	+38 0 0.4	*AG Lund* 4003	11	13 7 13.02	−26 14 53.6	*Cordoba A* 9781
4	8 55 26.11	+34 11 1.5	*AG Leiden* 3721	12	13 12 17.23	−27 39 48.7	*Cordoba B* 8439
5	9 23 16.01	+31 43 23.9	*AG Leiden* 3876				
6	9 12 29.99	+29 16 38.9	*Astr Oxf* +29.0940, 28063; +30.0945, 23882				

NOTE

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BENJAMIN BOSS, *Editor*

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